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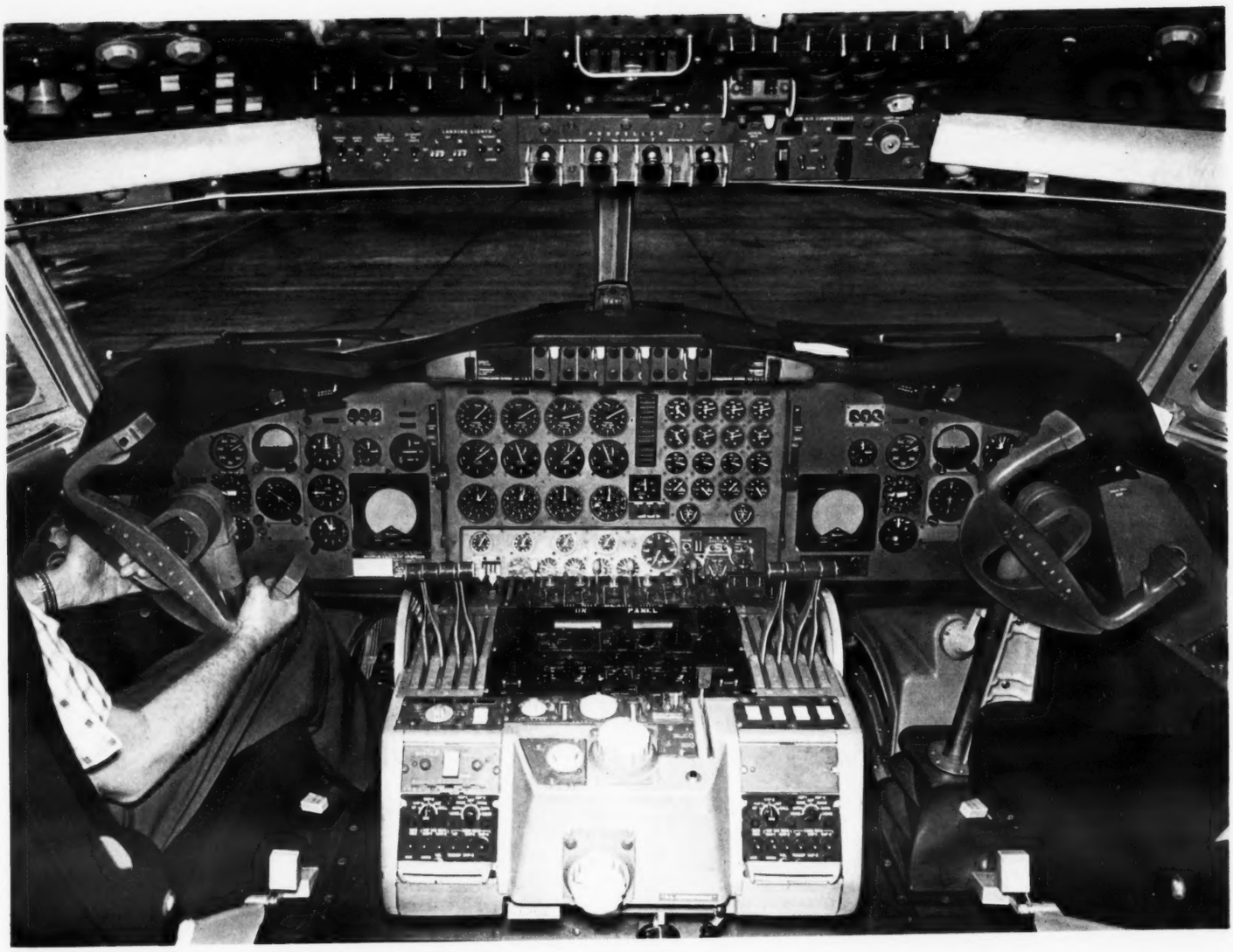
WORLD REVIEW OF AVIATION AND ASTRONAUTICS



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Space Vehicles — Weapons System without Weapons

VOLUME XIV

No 4/1959

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Volume XIV

INTERAVIA

April 1959

WORLD REVIEW OF AVIATION AND ASTRONAUTICS

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FRONT COVER: *The cockpit of the Lockheed Electra turboprop airliner . . .* shows not only the conventional instruments but also a number of new electronic control units and indicators for flight control, radio navigation and communications. Immediately in front of the joysticks are the Approach Horizon and Course Indicator for the Collins IFS in dual installation; a little further towards the centre are the two daylight screens for the Bendix weather radar; finally the centre panel fairly bristles with control units for radio equipment and autopilots.

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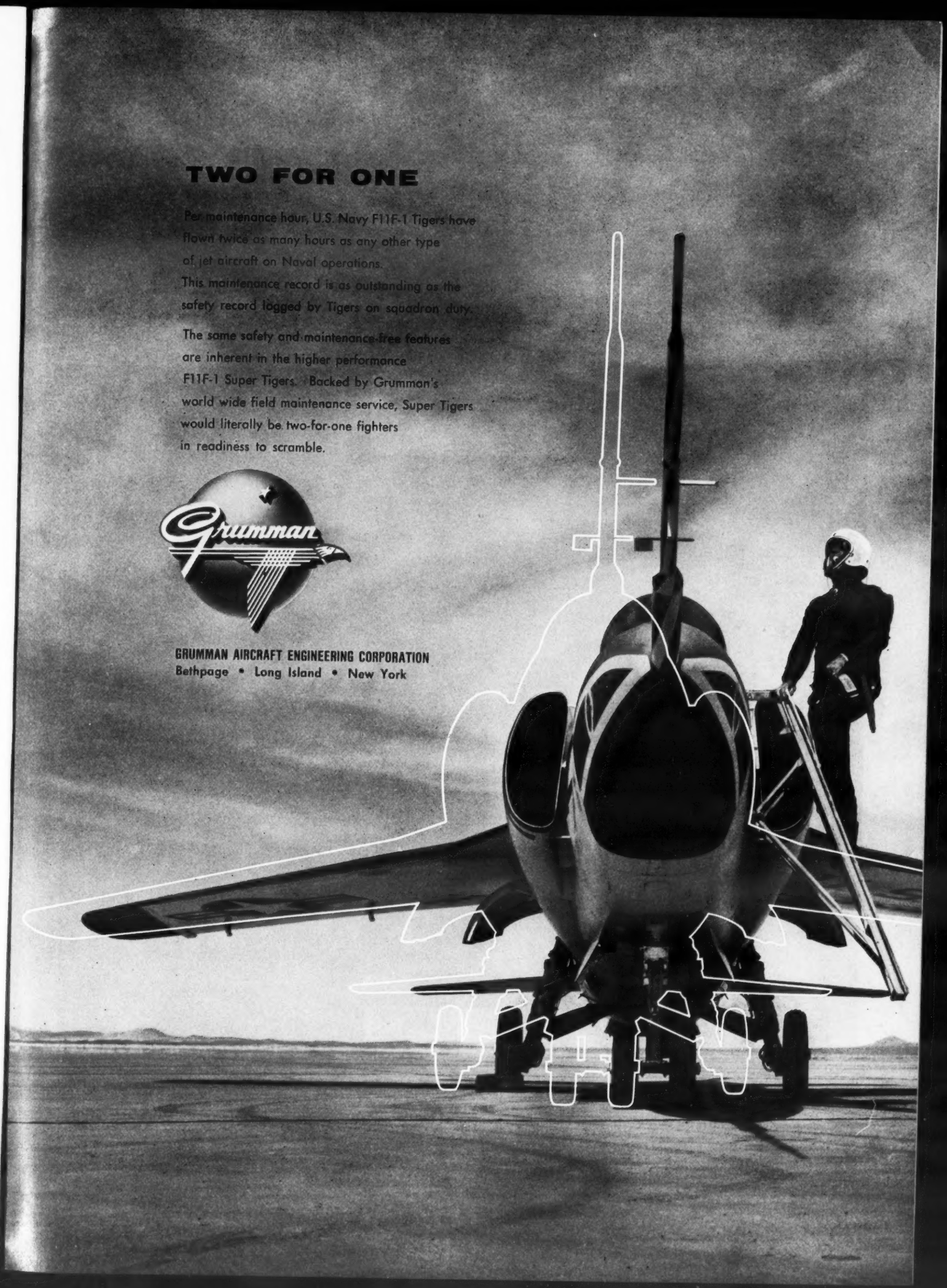
TWO FOR ONE
Per maintenance hour, U.S. Navy F11F-1 Tigers have flown twice as many hours as any other type of jet aircraft on Naval operations.
This maintenance record is as outstanding as the safety record logged by Tigers on squadron duty.
The same safety and maintenance-free features are inherent in the higher performance F11F-1 Super Tigers. Backed by Grumman's world wide field maintenance service, Super Tigers would literally be two-for-one fighters in readiness to scramble.
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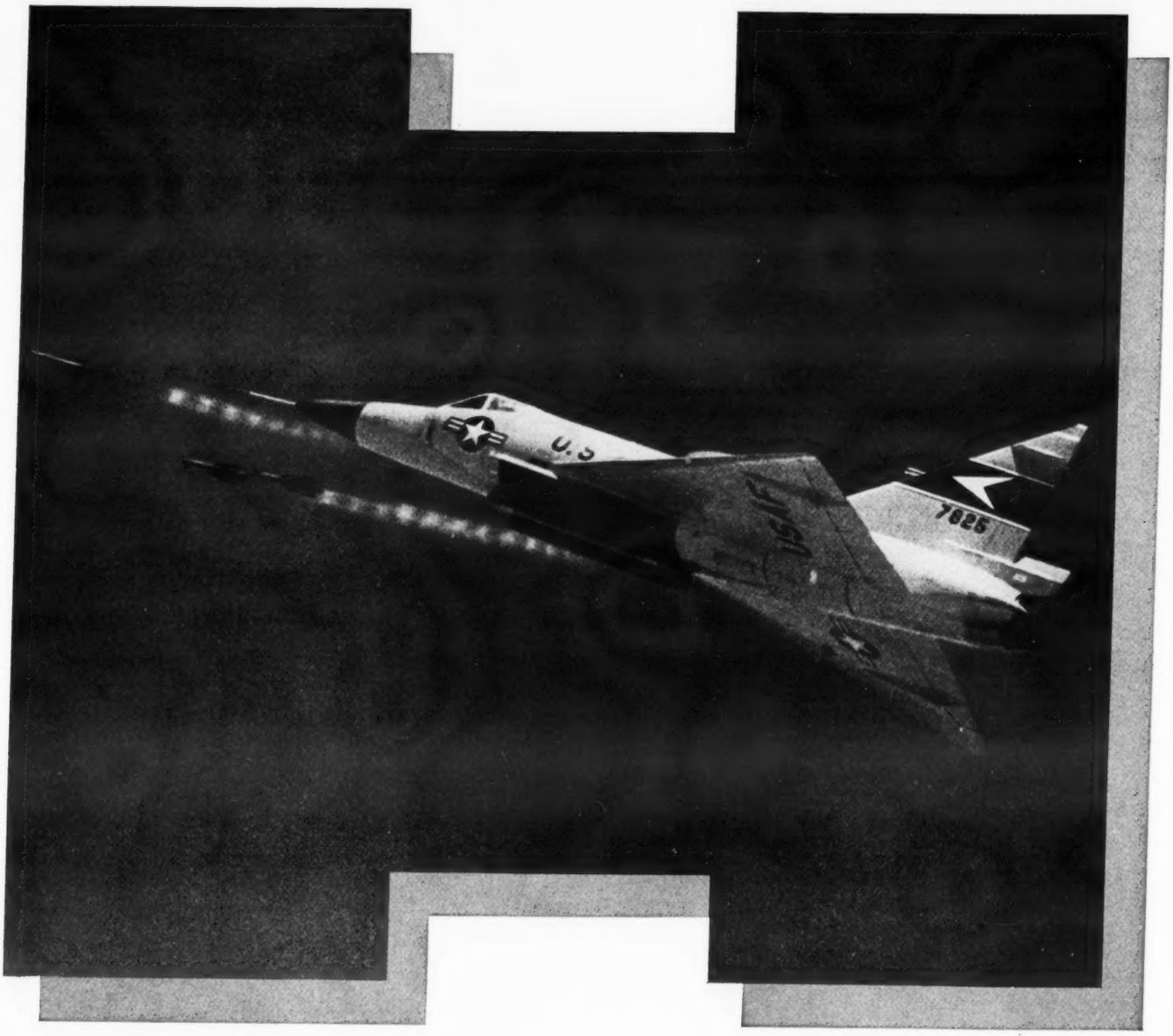
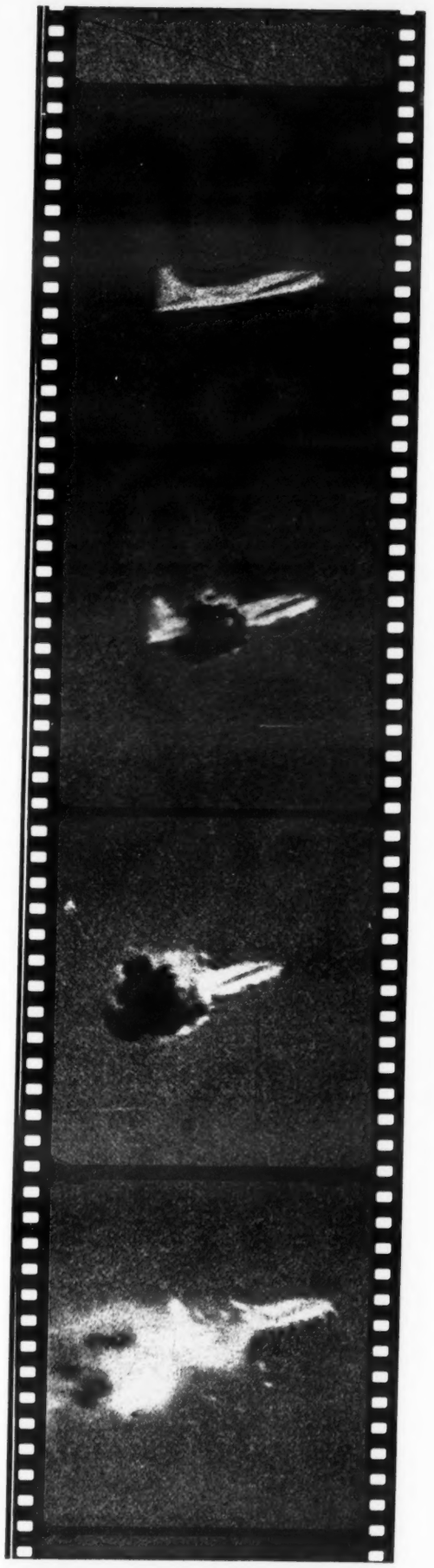
There's a new Falcon



in the sky

Falcon guided missiles with both radar and infrared guidance systems are today's best performing air-to-air missiles.

Enemy-killing Falcon missiles have proven their accuracy against all types of targets. In recent competition at the Tyndall Air Force Meet, Falcons had 87.4% average hits.



SOON TO BE BASED ON EUROPEAN SOIL are Convair F-102 interceptors that carry both the radar and infrared guided Falcon missiles. Manufactured by the Hughes Aircraft Company, these Falcon missiles provide the first all-weather capability of supersonic interceptor aircraft.

Guidance, control and auxiliary systems of both radar and infrared Falcon missiles are installed in a space no larger than a few feet of stovepipe. Falcons are capable of supersonic speeds to overtake and destroy their targets. Radar-guided Falcons continuously compute the target's position to steer a collision course to the predicted point of impact. Infrared-guided Falcons, on the other hand, steer toward the detected source of infrared energy: the target's engines.

Falcons can be fired singly or in salvo. When "mixed loads" of GAR-1D and GAR-2A Falcons are carried, the interceptor has great versatility of attack. Circumstances determine which type of missile to use, and the pilot bases his decision on prevailing tactical conditions.

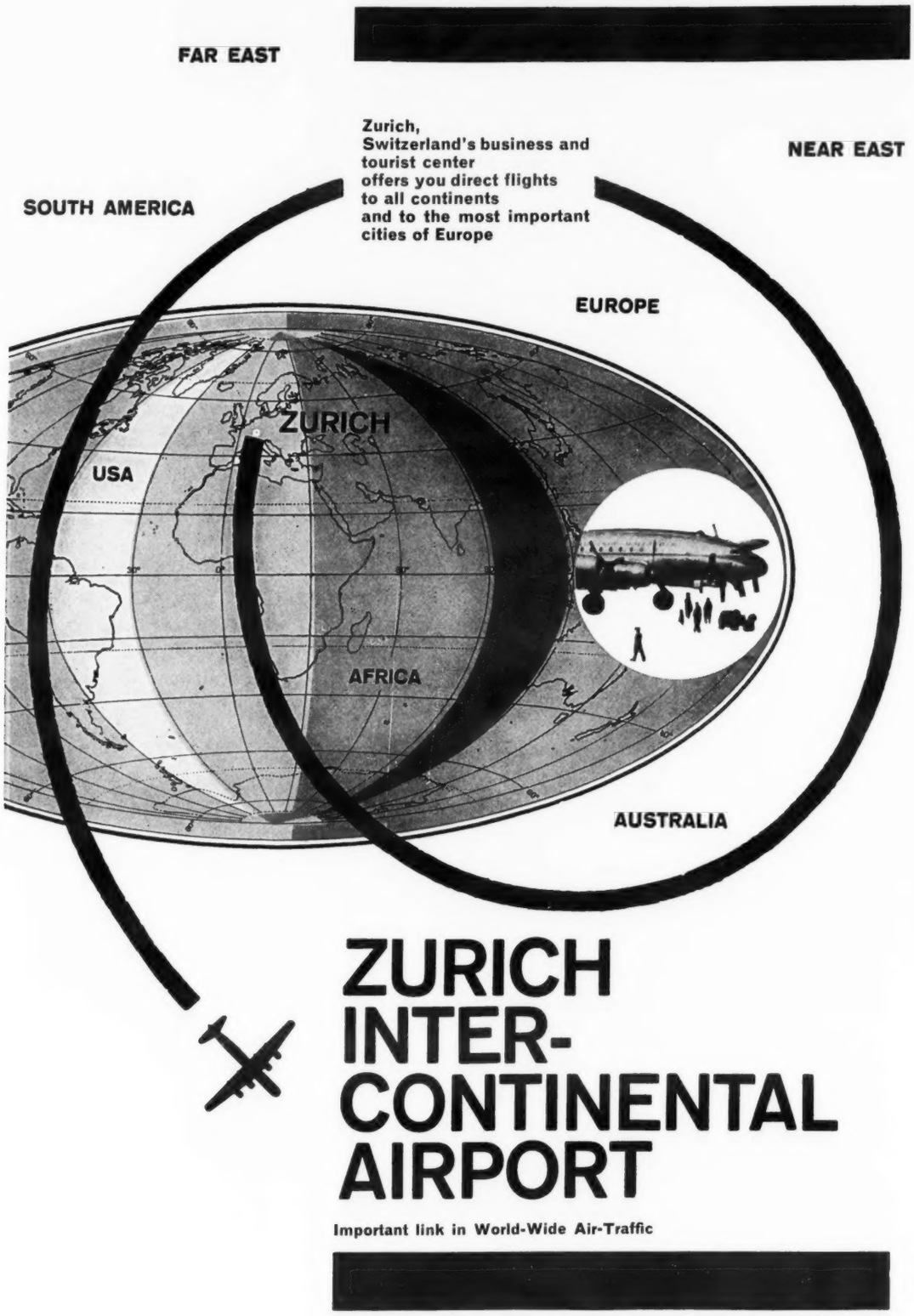
It was in 1948 that Hughes developed the first all-weather electronic control systems which launch the Falcon missiles. Since then new systems have been developed continuously to meet the needs of supersonic speeds and high altitudes.

The Hughes electronic armament system seeks out the enemy target many miles away, flies the interceptor to the target, automatically launches air-to-air guided missiles, and flies the interceptor back to its home base.

Both the Hughes electronic armament system and Falcon missiles are being mass-produced by Hughes for the U.S. Air Force and have proven their outstanding reliability through extensive use. Hughes electronics systems have been installed in the U.S. Air Force F-86D, F-89H, F-94C, F-101B, F-102A and F-106 interceptors—plus systems for the U.S. Navy, Royal Canadian Air Force and Belgian Air Force. America's planes of tomorrow, now on the drawing boards, will have Hughes electronics systems and advanced Falcon missiles.

For further information regarding these advanced Hughes systems please write to Hughes Aircraft Co., International Division, at the address below.

HUGHES AIRCRAFT COMPANY
CULVER CITY, CALIFORNIA, U.S.A.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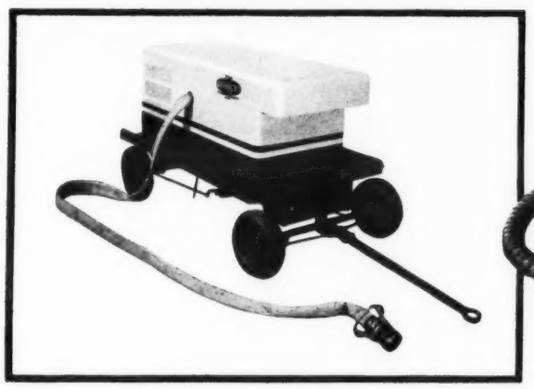

Gas turbines have been proved in the field as the most versatile and reliable power sources for the ground support of both commercial and military jet aircraft. AiResearch gas turbines have started more jets than those built by any other manufacturer.

Besides starting main engines, these ground support units supply continuous flow pneumatic power for air conditioning and heating, compartment pressurization, snow and ice removal, and electrical power for checkout and ground operation of electrical systems.

They allow completely automatic, pushbutton operation and run on any jet engine fuel or ordinary kerosene. They provide immediate starting without warmup and operate in weather extremes from −65°F to +130°F. Each model can also supply 400 cycle electrical power with the addition of a 60 to 80 KVA alternator.

A Volkswagon truck, with an AiResearch unit, becomes a complete pneumatic and electric power plant, with all parts easily accessible through wide doors. It provides greater ease of handling because it can be driven frontward into position and can be operated from inside the heated cab.

A Trailer unit provides pneumatic and electrical power and can be towed singly or as part of a train to wherever needed.

A Fly-away air transportable unit—the same turbine and control panel as used in the vehicles can be placed in an airplane's luggage compartment for use in occasional or widespread flight operations and emergency starts. It is equipped with lightweight skids and handles.

The Garrett Corporation, through its AiResearch divisions, is the world's largest producer of small gas turbines—8,000 in operation. For information, write The Garrett Corporation, 26 Rue de la Confederation, Geneva, Switzerland.

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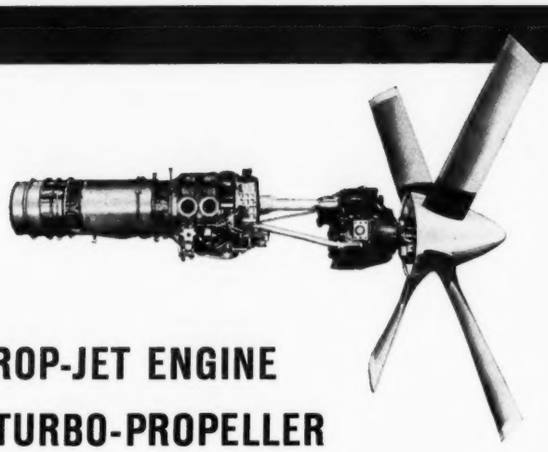

ALLISON PROP-JET ENGINE AND AEROPRODUCTS TURBO-PROPELLER

This matched GM power team is bringing jet-age speed, comfort and economy to flights of all ranges. Combining jet power with the advantages of the propeller, the Allison engine operates on the turbine principle. The power is absorbed by the turbine and transmitted to the propeller which provides the thrust to pull the airplane instead of push it as with pure jets. This prop-jet powerplant produces immediate power response, enables shorter take-off runs from present airports. On landings, too, the braking action of the propeller is constantly available for positive stops on short, wet or icy runways.

The Lockheed Electra, powered by the Allison 501 and Aeroproducts Turbo-Propeller, fits existing air traffic control patterns... flies without penalty at altitudes up to 30000 feet... brings jet-age speeds, comfort and economy to short and medium ranges as well as flights up to 3000 miles nonstop.

This GM jet power team is backed by more than 14 million hours of jet-age flight experience as well as General Motors' world wide reputation for dependable power covering every form of transportation — land and sea as well as air. No wonder so many leading airlines are building their jet-age futures **now,** with the GM jet power — Allison Prop-jet engines and Aeroproducts Turbo-propellers.

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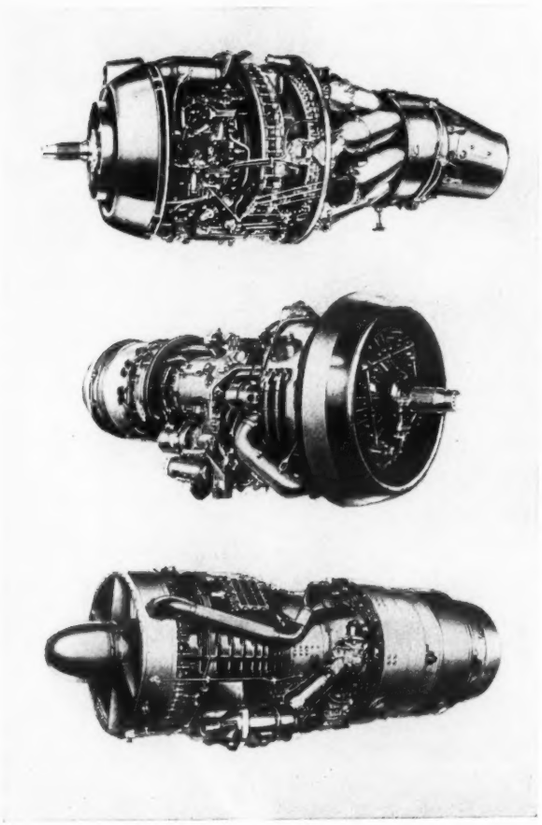
has now been granted a full certificate of airworthiness by the Air Registration Board at a minimum rating of 18,000 lb. thrust.

ROLLS-ROYCE EXPERIENCE IN THE AIRLINE OPERATION OF GAS TURBINES IS UNIQUE



THE DART

—the first, and for four years the only prop-jet in airline service has flown over 7,000,000 hours. The Dart is currently operating at overhaul lives of up to 2,300 hours.

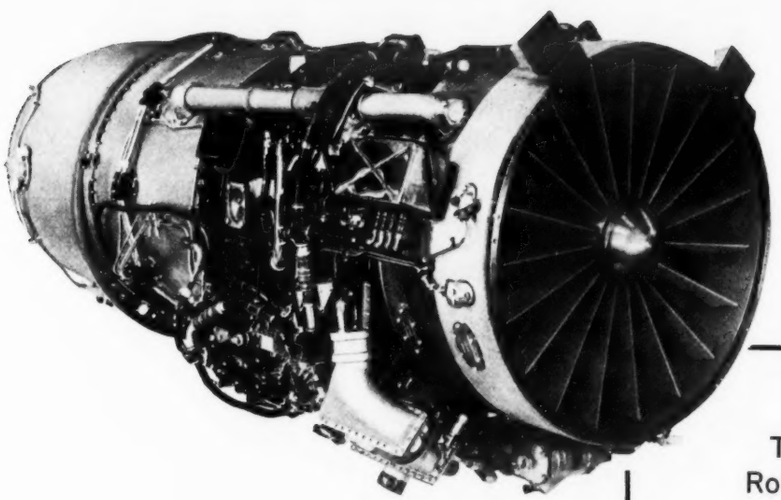
THE TYNE

—a most advanced prop-jet engine, is due to enter service in 1960 at ratings of 4,985, 5,525 and 5,730 e.h.p. It has a specific fuel consumption comparable with the latest compound piston engines.

THE AVON

—the first turbo jet on the North Atlantic route, and now in daily service, began scheduled operations with an approved overhaul life of 1,000 hours.

IN JET POWER



DEVELOPED FROM EXPERIENCE

The by-pass principle which Rolls - Royce have proved in the Conway engine is now accepted as the correct formula for all jet transport and for certain military applications.

The new RB.141 family of by-pass jet engines is based on seven years' development experience of the by-pass principle gained with the Conway and on six years' operation of other gas turbine engines in airline service. The first of this series has already been chosen to power the new British European Airways medium range jet airliner.

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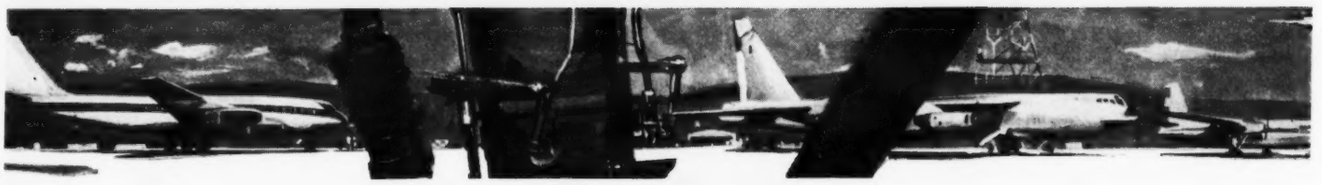

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These tires have proved themselves in pounding after pounding in repeated high-speed landings, and they provide vital weight-savings, simplify inventory and service.

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For complete information, write: Goodyear International Corporation, Aviation Products Division, Akron 16, Ohio, U.S.A., or The Goodyear Tyre & Rubber Company (Great Britain) Ltd., Wolverhampton, England.

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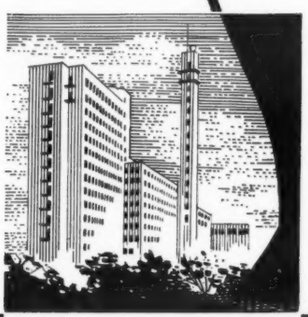

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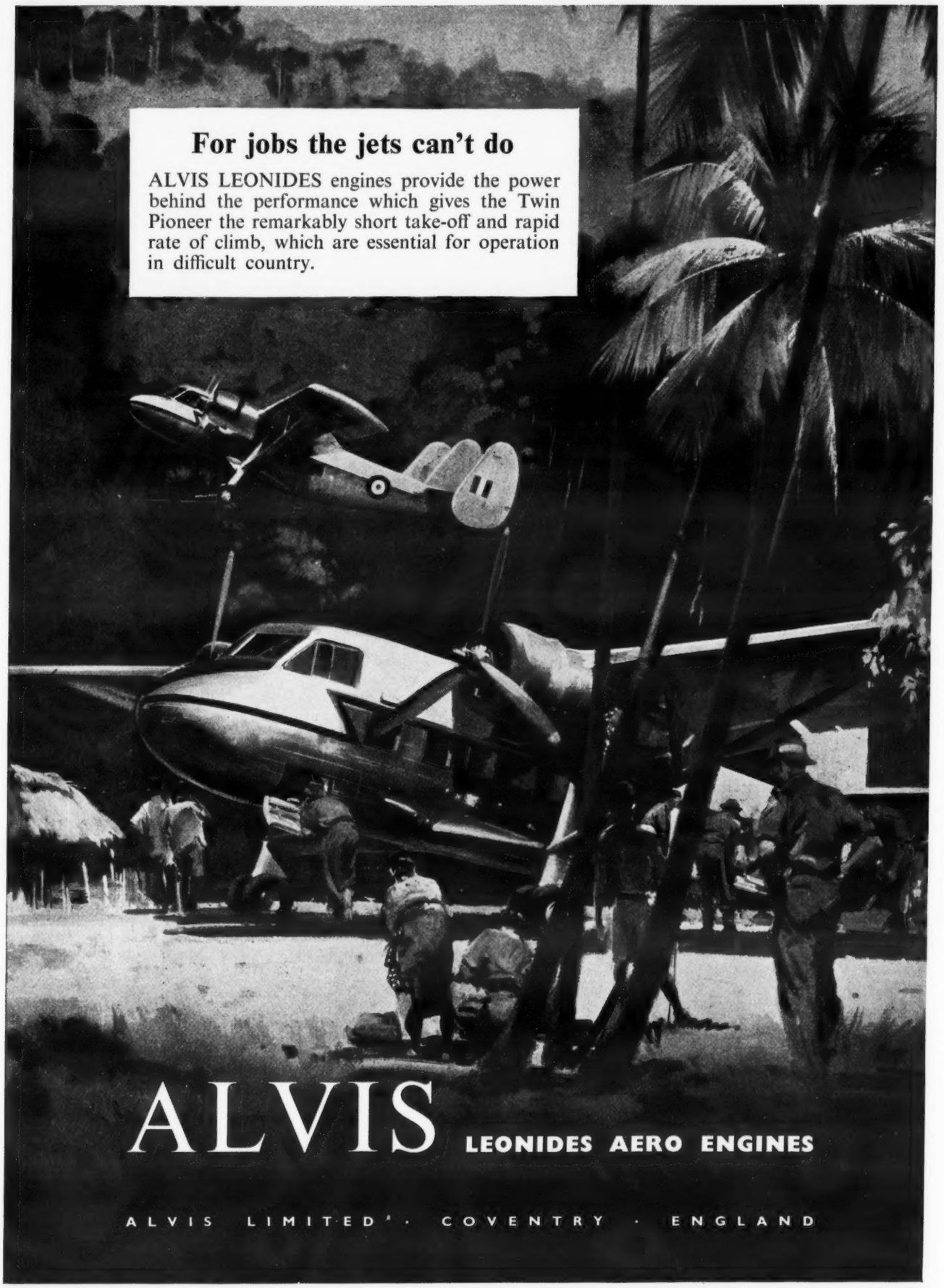
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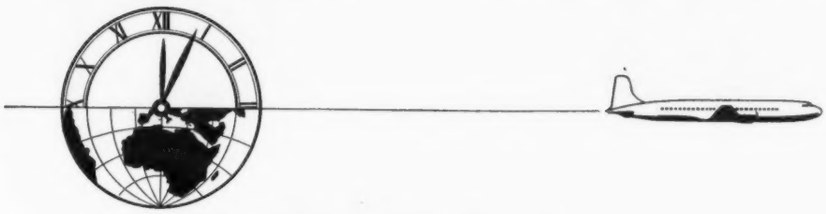

Deadline Notes

The International Air Transport Association Clearing House in London last year cleared a total of $820,500,000 (£292,000,000) in international airline business; the record 1958 figure is 28 percent above the 1957 peak of $639,000,000 (£231,000,000). Member airlines dollar and sterling counter claims eliminated the necessity for cash payment of 88.9 percent of all transactions cleared through IATA during 1958. Interclearances with the Airlines Clearing House, Inc. totalled $31,468,594 for the period, up 18 percent from 1957. The cost to members was less than 14 cents per $1,000 of Gross Receivables. Total turnover for the 12-year period of IATA clearing operations now amounts to $3,640,000,000 (£1,300,000,000). The number of member airlines increased from 85 to 94.

●

Trans World Airlines will introduce a once-weekly non-stop service Chicago-London on June 5th, 1959. TWA will use L-1649A transports, departing Chicago each Friday; flying time 13 hours 10 minutes. A non-stop service in the reverse direction London-Chicago is planned to commence on August 1st, 1959, with a flight time of 15 hours 50 minutes.

●

The Civil Aeronautics Board has recommended approval of American Airlines' application to operate non-stop services New York-San Francisco, in competition with Trans World Airlines and United Air Lines. American Airlines currently operates non-stop flights New York-Los Angeles. CAB said that a third non-stop service is desirable because the employment of jet aircraft over the route will stimulate traffic by about 10 percent.

●

Trans-Canada Air Lines may introduce the first Douglas DC-8, scheduled for delivery in early 1960, on to the Vancouver-Montreal route. TCA Director of Planning David Tennant said that this could bring lower transcontinental fares, but that the carrier would first wait to see what competition Canadian Pacific Airlines offers on trans-Canada routes before making a decision. Tennant also said that the carrier is seriously studying 55-70 seat VTO aircraft for short-haul routes.

●

Pacific Western Airlines of Vancouver has applied to the Air Transport Board to take over Canadian Pacific Airlines' prairie routes from Edmonton to Uranium City, Yellowknife, Peace River, and Fort McMurray. CPAL has agreed to withdraw from these routes in favour of PWA. PWA would set up a new operating base at Norman Wells, from which *Otters* would serve the Northern route, and service facilities at Edmonton would be increased. PWA is reported to be seriously considering turboprop aircraft for its British Columbia services and the proposed prairie routes.

●

Trans-Canada Air Lines has appointed A. J. Bartok as District Sales Manager for the company in Austria. Bartok will have his office in Vienna, and will arrive in Austria in March to prepare for the inauguration of TCA's *Super G Constellation* service on the Montreal-Brussels-Dusseldorf-Vienna route on May 1st, 1959. Bartok, who is a Canadian citizen, will also be responsible for TCA sales in Poland, Czechoslovakia, Rumania and Hungary.

●

British Overseas Airways Corporation's summer schedules will include three non-stop *Britannia* flights per week Detroit-London, departing Detroit on Sundays, Wednesdays and Thursdays; flying time Detroit-London is 11 hours. A further two flights weekly will be operated Detroit-Shannon-London, and another two Detroit-Prestwick-London. First-Class, Tourist or Economy travel will be available on all these services.

●

Swissair Board of Directors on March 11th approved the 1958 accounts for presentation to the annual general meeting on April 9th, 1959. Receipts totalled 252,000,000 Swiss francs (210,000,000 Swiss francs in 1957), and expenses, including depreciation and reserves amounting to 28,500,000 S. fr., were 247,000,000 S. fr. (207,000,000 in 1957). Net profit for the period was 5,101,613 S. fr., plus à carry-over of 367,057 Swiss francs from the previous year. The Board proposes the distribution of a six percent dividend, as for last year. 600,000 Swiss francs will be transferred to the statutory reserve, and 1,000,000 S. fr. to the general personnel retirement fund. The balance of 403,670 S. fr. will be carried forward to the next accounting period. The Board also proposes an increase of registered capital from 63,000,000 to 105,000,000 Swiss francs by the issue of 120,000 registered shares at a nominal value of 350 francs each.

●

Swissair and Balair held a joint press conference in Basle in mid-March to announce the signature of a commercial, technical and operating contract between the two companies. The object of the agreement is to promote Swiss participation in charter traffic, on a sound economic basis. The contract will run for ten years, with possible extension for a further five, and covers a 40 percent Swissair participation in Balair capital, which is to be increased in April next from 750,000 Swiss francs to four million Swiss francs. Swissair participation will be limited to 40 percent, and a majority holding is not considered. Swissair is selling Balair two fully overhauled Douglas DC-4s which are no longer required for scheduled operations, and the aircraft will be handed over on April 10th and May 29th. The sales contract is on very favourable terms, and so designed to avoid imposing any financial difficulties on Balair. Future cooperation between the two carriers will be largely in the field of aircraft procurement, operational planning, sales and traffic, publicity, etc., by which Balair will benefit from Swissair's world-wide organization.

●

The Boeing Airplane Company announces that Irish Air Lines (Aerlinte Eireann Teoranta) has ordered three Boeing 720 jet transports; this follows the carrier's recommendation to the Irish Government that jet aircraft should be purchased for operation on trans-Atlantic services. Estimated cost is approximately £4,200,000 and delivery is expected in late 1960 and early 1961. The Irish Air Lines 720s will have a maximum gross weight of 217,000 lb.—higher than that of the version ordered by the United States carriers. Powerplant will be an improved and specially developed version of the Pratt & Whitney J57. Maximum range with full passenger payload (153 Tourist Class) is 3,550 miles; maximum cruising speed is 615 m.p.h. The total of 720s on order is now 39 (American Airlines—25, United Air Lines—11).

●

The Sikorsky Aircraft Division of United Aircraft Corporation has received an order from Los Angeles Airways for two turbine-powered S-62 helicopters which are to be put into service in early 1960. Los Angeles is also negotiating the purchase of the Sikorsky S-61, a 25-seater turbocopter which is expected to be available early in 1961; the carrier is currently operating five Sikorsky S-55s and two Sikorsky S-51s to carry passengers, mail and cargo over a wide spread network throughout the greater Los Angeles area. Three other helicopter operators have also taken options to purchase the S-62; they are Rotor Aids, Inc. of Ventura, Calif., Petroleum Helicopters, Inc., of New Orleans, and Aero Service Corp. of Philadelphia.

●

The U.S. Army has announced that it will negotiate with Vertol Aircraft Corporation to develop the YHC-1B *Chinook*, the Army's new two-to-three-ton capacity transport helicopter, which will eventually replace the piston-engined models. Vertol is currently building a quantity of the Army YHC-1A version of the aircraft. Detailed technical specifications for the YHC-1B have not yet been completed. Some data on the YHC-1A: powerplant is two Lycoming T53-L-1 turbine engines of 825 h.p. each; seating capacity for 22 soldiers, a commander and two crew. Take-off weight 15,550 lb. (7,050 kg); diameter of the three-blade rotors 48 ft. 4 in. (14.7 m); length with folded rotor blades 44 ft. 3.6 in. (13.5 m); height 17 ft. 7.5 in (5.4 m).

●

Bell Helicopter Corporation has received U.S. Army contracts totalling $23,000,000 for the production of 110 HU-1A turbine-powered helicopters and 60 H-13H piston-engined helicopters. A spare parts order for both aircraft will be issued later.

●

General Electric Company has redesignated its Aircraft Gas Turbine Division the Flight Propulsion Division. General Electric is currently building or developing five military engines (J79, J85, J93, T58 and T64) and two commercial engines (CJ-805-3 and CJ-805-21). Division General Manager John B. Montgomery said that the division expects to expand its activities in nuclear power, ion and photon engines and other still classified propulsion systems.

●

Fairchild Engine & Airplane Corporation has announced the closing of its Deer Park, Long Island, plant due to insufficient contract awards. In January 1959 the company laid off 2,000 of its Deer Park employees when the Air Force cancelled its contract for the Fairchild J83 lightweight jet engine. The plant will be put up for sale.

●

The Senate Space Committee has appointed Senator Stuart Symington to head a seven-man subcommittee to study the Government's whole space programme, currently being conducted by a total of fourteen different agencies. The subcommittee has been detailed to find out what each of the agencies is doing, to forestall inter-agency conflicts and to recommend the necessary legislation. In particular, the group will look for costly duplication in the va-

rious space programmes, which can be eliminated.

●

The Ministry of Supply has placed a pre-production contract with Saunders Roe Ltd. for the supply of an unspecified number of P.531 five-seat multi-purpose turbine-powered helicopters (powerplant Blackburn *Turmo 600*). Saunders Roe has developed the P.531 as a private venture with the remarkably short time of six and a half months' work from start of the design proper to first flight. Further data : range (with normal fuel reserve) 210 nautical miles, cruising speed approx. 100 knots, maximum speed 105 knots, take-off weight 3,800 lb.

●

General Aldo Rossi has been nominated Defence Chief of Staff to succeed General Giuseppe Mancinelli. General Bruno Lucini will succeed General Giorgio Liuzzi as Army Chief of Staff. Mancinelli and Liuzzi are both due to retire on April 1st, 1959. General Rossi now commands Allied Forces Southern Europe, and is also representing Italy in the negotiations with France and Germany on the question of a joint armament production organization. General Lucini is Commander of the 3rd Army at Padua, and is a former Secretary-General of the Italian Defence Ministry.

●

Federal Defence Minister Franz Josef Strauss signed on March 18th, 1959, the formal contract with Lockheed Aircraft Corporation covering the purchase of 96 Lockheed F-104 *Starfighters* (30 F-104Bs and 66 F-104As), and the licence production of a further two hundred Lockheed F-104s in the Federal Republic. The first *Starfighters* from the States are scheduled for delivery at the end of this year. Manufacture of the Lockheed F-104 in West Germany will be undertaken by Flugzeugunion Süd (Dornier, Messerschmitt and Heinkel). The price of a German-produced *Starfighter* will be DM 5,000,000 ($1,190,476) ; the aircraft manufactured in the States will cost DM 5,800,000 ($1,380,950). Both figures include approximately DM 1,300,000 ($309,524) for the provision of electronic and weapons systems specified by the West German Air Force. Also in Bonn on the same day a formal contract was signed with General Electric's Flight Propulsion Division for the purchase and licence production of the J79 jet engine which will power the German Air Force's *Starfighters*. General Electric's Evendale, Ohio, plant will supply the powerplants for the 96 *Starfighters* to be delivered from the States, as well as complete components for the assembly of a number of units in the Federal Republic. No details are yet available on the licence production of the J79 powerplants by West German firms. A similar contract with Fiat for the purchase and licence production of the G-91 light strike fighter was signed on March 11th, 1959.

●

Estimated Defence Ministry expenditure for fiscal 1959-1960 (July 1st to June 20th) totals 619,494,300,000 lire. This sum is allocated as follows: 126,345,850,000 for military aviation (25.4 percent); 19,600,000,000 for infrastructure, territorial air defence and new weapons (3.16 percent); 6,341,656,000 for civil aviation (1.02 percent). The Ministry of Public Works will finance Rome-Fiumicino Airport development, postal and telecommunications expenses, and payment for air mail. The Istituto Ricostruzione Industriale will be responsible for Alitalia capital expenditure and subsidies.

●

D. Napier & Son Ltd. has received a £100,000 contract for turbine blades from the East German Government. The order, which is the first for castings to be received by Napier from an overseas customer, was secured in competition with both British and foreign firms, and was signed at Leipzig.

●

The Canadian Government and the services have been investigating a number of aircraft for re-equipping the eight squadrons of *Sabre* jets serving with Canada's air division in Europe, but no decision yet been taken. Defence Minister Pearkes has emphasized that discussions must first be held with NATO chiefs on the roles for which the air division might be best suited. The RCAF is said to favour the Grumman *Super Tiger* F11F-1F. Visits have also been made to Northrop, Lockheed, Republic in the States and to Blackburn and General Aircraft in the United Kingdom.

●

Norad (North American Air Defence Command) has announced that the BMEWS (Ballistic Missile Early Warning System) long-range radar, currently under construction in the Arctic from Alaska to Greenland, will have three stations at Clear, Alaska and four at Thule, Greenland. The BMEWS chain will have a 3,000-mile line of sight range. The cost of the system to the USAF is about $1,000,000,000, according to a Norad statement. Enemy ICBMs will be spotted five minutes after launching and the data will be fed to Norad headquarters, Colorado Springs, Colorado and USAF Strategic Air Command at Omaha, Nebraska. The BMEWS chain will give something like twenty minutes time for decision on a counter attack. Until United States ICBMs are fully operational, any such counter attack would be carried out by SAC bombers carrying nuclear weapons.

Workshop Briefs

The Vickers Vanguard has logged 50 hours in the air (up to March 11th), since its first flight on January 20th, 1959. This total was built up in 21 flights.

●

The Armstrong Whitworth Argosy second prototype has begun test flights.

●

The four-jet McDonnell 119 multi-purpose and VIP aircraft recently commenced flight tests. For the first test phase the 119 is still fitted with down-rated Westinghouse J34s, but later the aircraft will be powered by four Pratt & Whitney J60 (JT-12) jet engines of 3,000 lb. thrust each. The 119 has a span of 57 ft. 7 in., wing area is 550 sq.ft., sweepback 35° at 25 percent cord, aspect ratio 6, and length 66 ft. 6 in. Maximum normal take-off weight is 40,928 lb.; maximum take-off weight for max. range 45,238 lb.; cruising speed for max. range 453 knots ; still air range (with reserves) 1,825 nautical miles.

●

The Dornier Do 29, which began flight tests at the end of 1958, and is derived from the single-engine Do 27 short take-off aircraft, is an experimental aircraft designed to investigate special aspects of short take-off and landing. The Do 29 is a high-wing monoplane of all-metal construction and fixed undercarriage. It is powered by two Lycoming GO-480 engines which drive pusher propellers tilting downwards through 90°. The airfoil is similar to that of the Do 27 ; span has been increased to 43 ft. 3 in. Take-off weight is 5,290 lb. In the coming months, the prototype will undergo extensive tests to check flying quality, take-off and landing performance, powerplant, etc.

●

Pacific and Western Aviation Company Ltd., recently founded in Australia, which is to take over the activities of the Special Projects Division of East-West Airlines (including the construction of the Millicer *Air Tourer* sports aircraft), announces that, following the production of a first batch of 25 two-seat *Air Tourers,* development of a four-seat version is to be commenced. It will be known under the designation *Air Cruiser.*

●

A new version of the C-130 Hercules transport, using both turboprop and turbojet engines, and incorporating boundary-layer control, is under development at Lockheed's Marietta, Georgia plant. The jet engine will be fitted in underwing pods and would blow a constant air flow over flaps, ailerons, rudder and elevators for STOL take-off and landing.

●

Three new U.S. anti-submarine weapons are mentioned for the first time. One is the small Mark 44 torpedo, which is said to be capable of attacking fast targets at great depths. The Mark 44 is a target-seeking torpedo, electrically propelled, and can be launched from both aircraft and surface vessels. Two aircraft-launched mines complete the trio of new weapons : these are designated Mark 52 and Mark 55, and can be launched from the latest high-speed aircraft at extremely high altitudes. They are both ground mines.

●

Two rare metals, scandium and neodymium, will soon undergo extensive testing for possible use in the missiles and space fields. The Union Carbide Metals Company has received $60,000 in Air Force contracts for the investigation of the properties of scandium, which has a density about equal to aluminium, but a considerably higher melting point. One pound of scandium will be produced for testing purposes and is expected to cost $20,000. The Nuclear Corporation, on the other hand, is already producing neodymium at an approximate sale price of 70 cents a gramme.

●

The Bell 47J Ranger helicopter can, if required, be equipped with larger fuel tanks with a capacity of 47.5 U.S. gals, which will increase range to roughly 300 miles.

●

The U.S. Navy reports from the U.S. capital that a design contest will shortly be announced for a successor to the Martin P5M *Marlin* flying boat (two Wright compound engines). The new aircraft will in particular be required to have a higher speed and range than the P5M.

●

The Royal Aero Club announces that the 100 kilometre closed circuit record for convertiplanes set up by the Fairey *Rotodyne* vertical take-off airliner at 190.9 m.p.h. on January 5th, 1959, has been officially confirmed by the Fédération Aéronautique Internationale.

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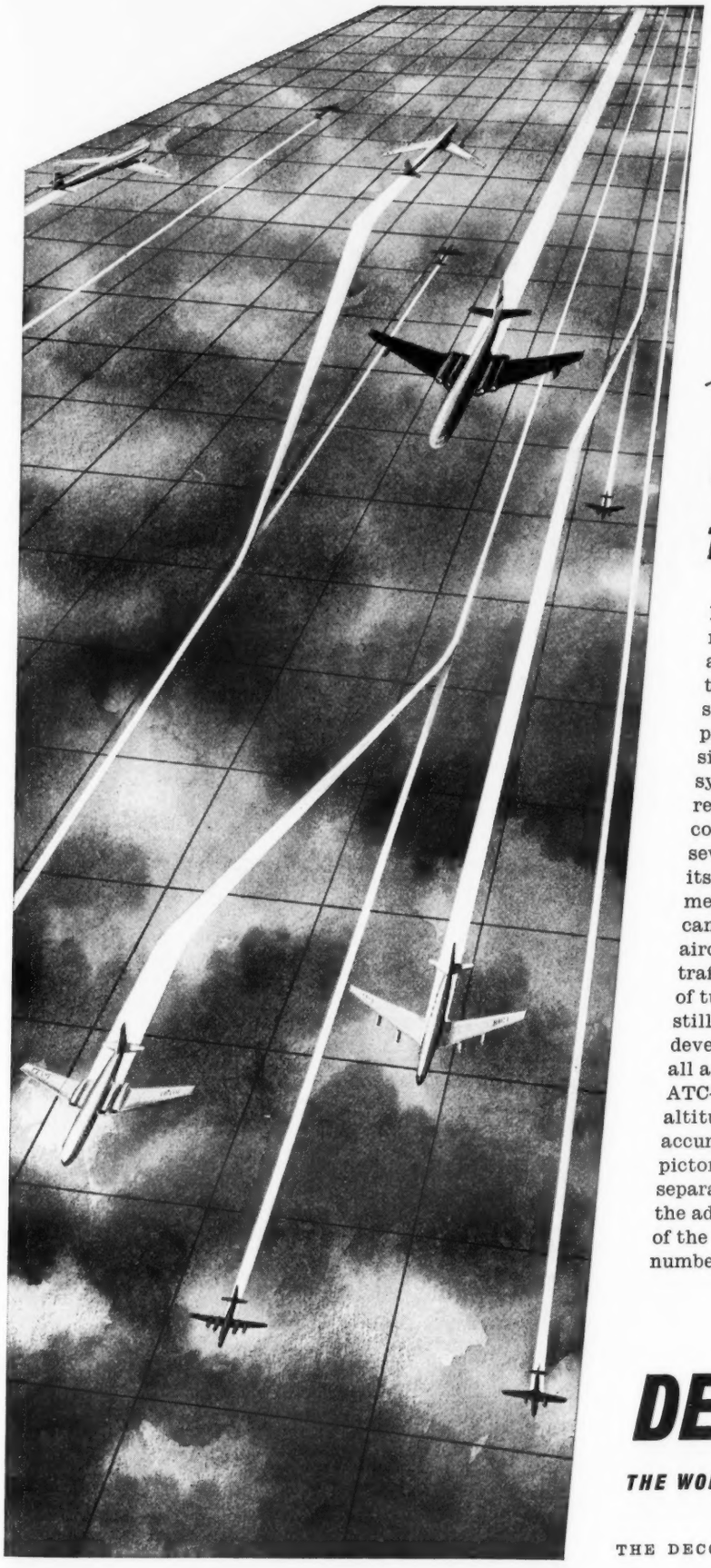

NAVIGATION for the JET AGE

From the dawn of aviation nothing fundamentally new has been added to the earliest principles of air traffic control. Until now these were founded on the requirements and limitations of relatively slow aircraft for which altitude separation was practical. Aircraft speeds and performance have since improved beyond recognition, but the basic system of navigation and air traffic control has remained virtually unchanged. Single tracks and common points of intersection are only two of the severe restrictions imposed on air traffic, threatening its very existence. The air, intrinsically a free medium, is swiftly becoming overcrowded and safety can only be maintained at the expense of inefficient aircraft operation, delays and over complicated air traffic control . . . a condition which the introduction of turbo-prop and turbo-jet aircraft will aggravate still further. Yet the answer exists today in a fully developed form. The Decca Navigator System enables all aircraft to navigate accurately and maintain any ATC-assigned track with precision, regardless of altitude, speed or weather conditions. This very accurate hyperbolic area coverage system, with its pictorial presentation, makes the introduction of lateral separation and "passing lanes" a reality. It is only by the adoption of such a system that full use can be made of the total air space, enabling the rapidly increasing numbers of aircraft to operate with safety and economy.

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Vertol Aircraft Reports on

Tandem rotor control

Years of operational experience in a wide variety of military and civil applications have conclusively demonstrated the control superiority of the tandem rotor helicopter.

With two lifting rotors, the tandem configuration generates strong control forces at each end of the fuselage, rather than at one end alone. The tandem's differential lift provides extremely powerful longitudinal control, resulting in greater safety, unsurpassed precision in hovering and in sling-load and towing missions and larger permissible center-of-gravity ranges. And since torque compensation is automatically assured by the counter-rotation of the lifting rotors, a tandem helicopter pilot need never adjust main rotor power for directional control. This means unmatched maneuvering precision in restricted areas.

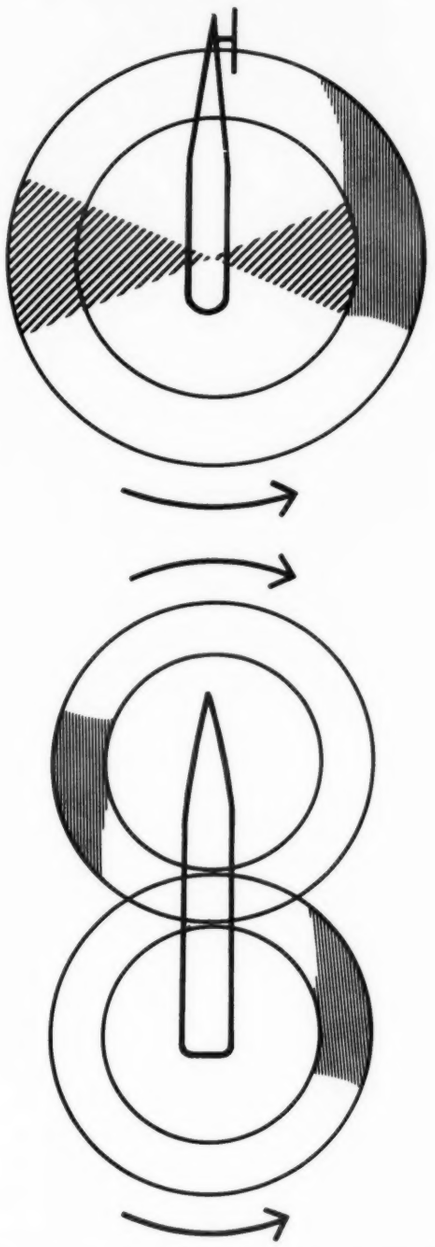
The control superiority of Vertol's pioneering tandem rotor design was again demonstrated during recovery operations following an airliner crash over

In Alaskan service, the rugged U. S. Air Force Vertol H-21 flies over mountains and glaciers in the roughest weather to evacuate the sick and rescue crash victims.

In an operation demanding the highest degree of control, Vertol H-21C helicopters flew through turbulence to the floor of the narrow Grand Canyon during a recovery mission.

BLADE STALL

Single vs. Tandem Rotor



Stall of the retreating blade (shaded area) is encountered in all helicopters at high forward speeds, high load conditions, high altitudes or turbulent air. It causes loss of lift on the retreating side of the rotor and therefore a rolling moment at the rotor shaft. In the case of the single lifting rotor (top view) this moment is transmitted to the fuselage and becomes uncontrollable when stall is extensive. In the case of the tandem (bottom view) the rolling moments of the two counter-rotating rotors compensate for each other with no rolling moment being transferred to the fuselage.

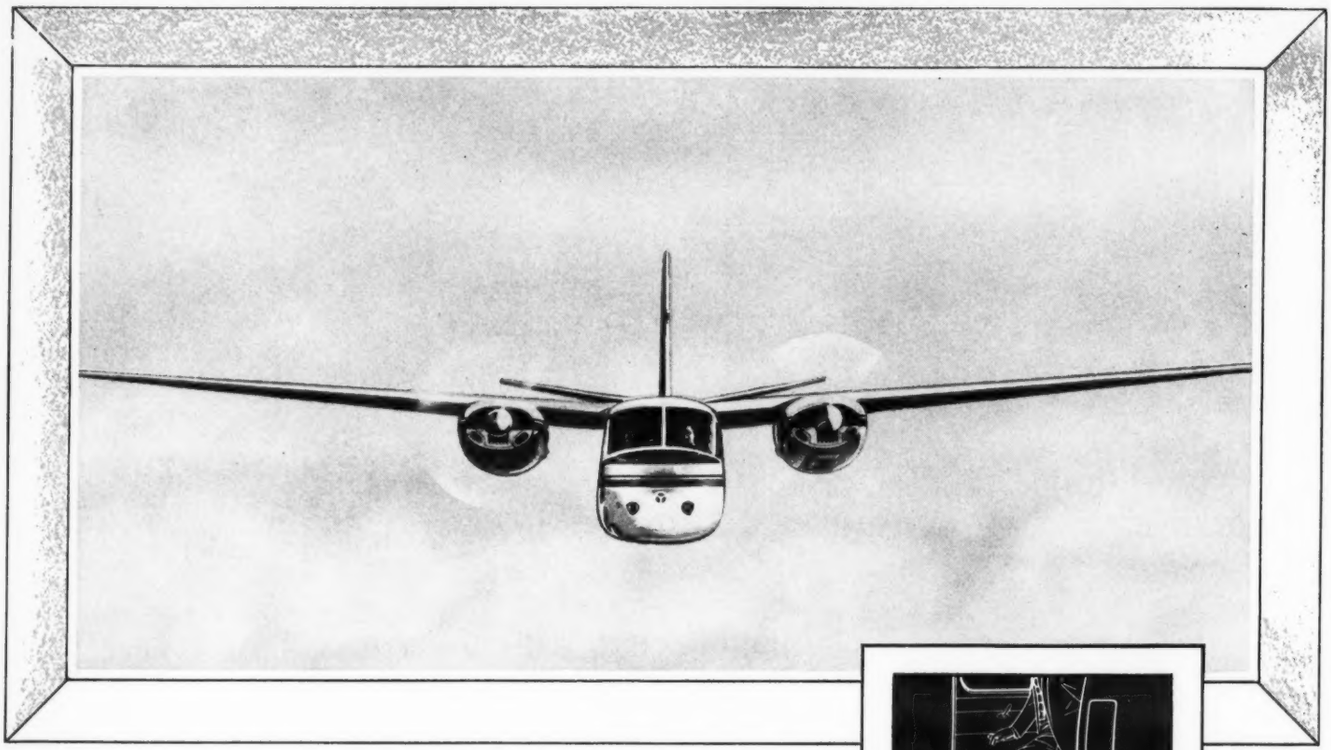
superiority

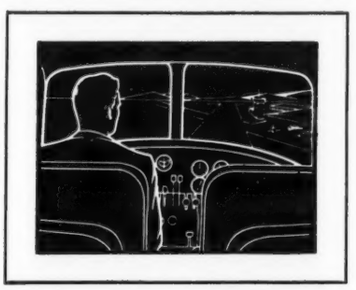
the Grand Canyon. After being advised by two pilots of single lifting rotor helicopters that "the canyon was too dangerous for helicopter operations in their particular type," four Vertol H-21C's completed 67 trips deep into the narrow, wind-swept depths of the canyon without incident. In addition, for two years many Vertol H-21C's have been demonstrating in daily operations in the mountains of Algeria the many advantages of the superior controllability of the tandem helicopter.

VERTOL Aircraft Corporation

MORTON, PENNSYLVANIA

SUBSIDIARY: ALLIED RESEARCH ASSOCIATES, INC., BOSTON, MASS.





Portrait of a Leader...

and the characteristics which spell superiority

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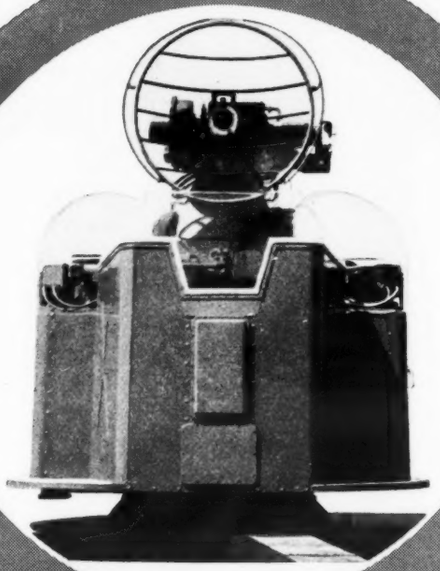

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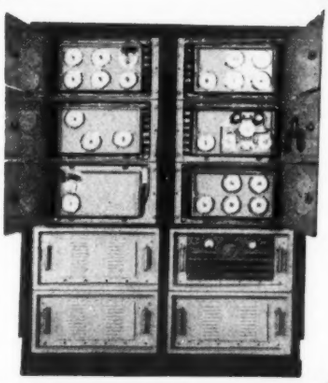
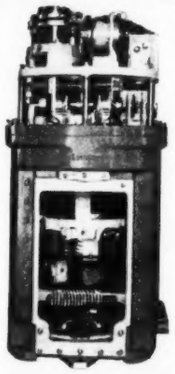
a vertical reference to provide stabilization data

a Type 90 analogue computer for precision weapon stabilization, tracking control, prediction, and calculation of the firing data





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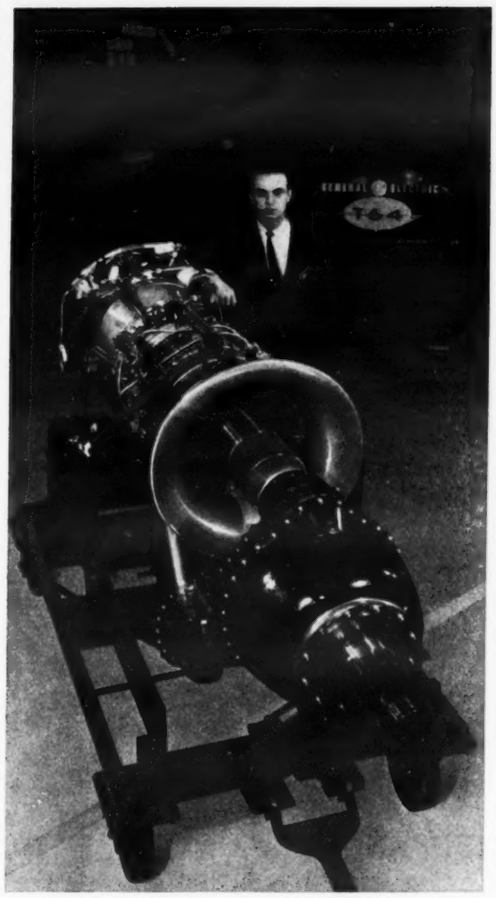
GENERAL ELECTRIC



T58

The T58 helicopter gas turbine, already in production, delivers more power per pound of engine, consumes less fuel per hp-hr than any other turboshaft flying today. Guaranteed at 1050 shp, 0.64 SFC, this 217-pound G-E powerplant has proven its high performance, ruggedness and reliability during extensive flight operations and environmental testing. Now on test is the 1250 shp first-step growth version.

T64

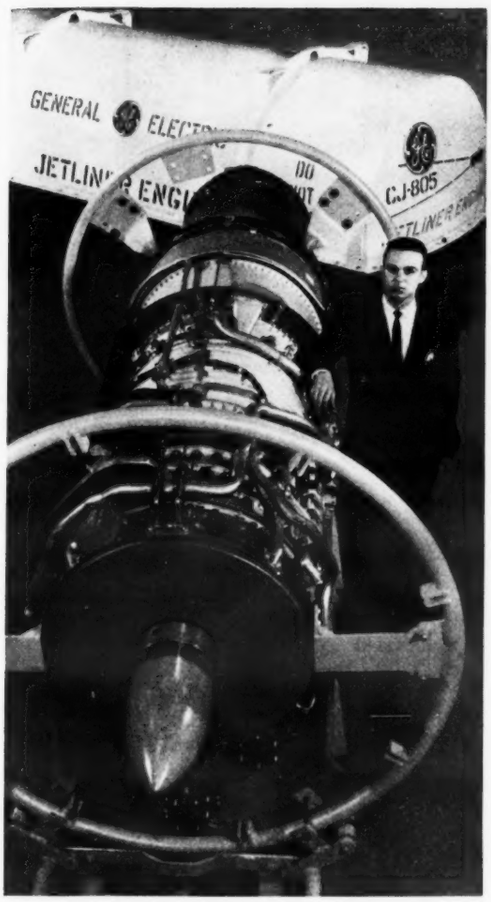
G.E.'s T64 is a turboprop/turboshaft engine in the 2600 horsepower class. This is a compact, versatile power package that can be used in either rotary-wing or fixed wing aircraft. It can also serve as a power source for radically-new airborne applications. General Electric's T64 is already on test and it is confirming its exceptional performance advantages.

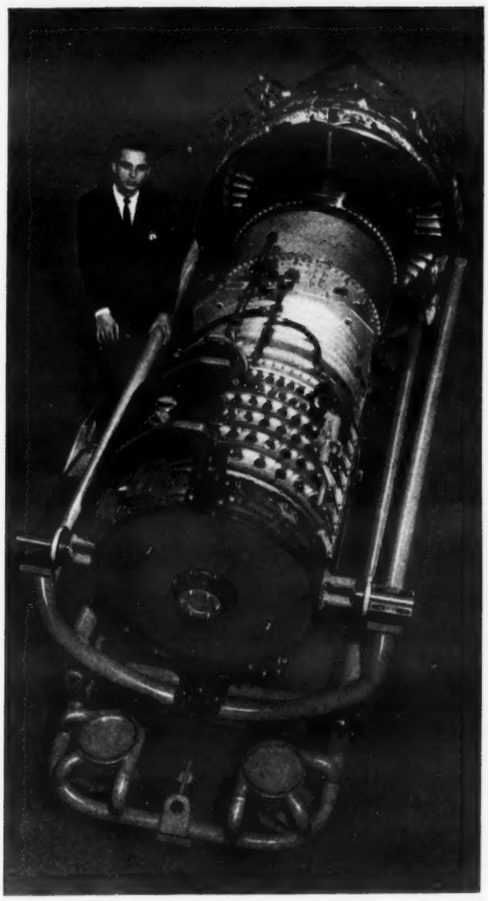
J85

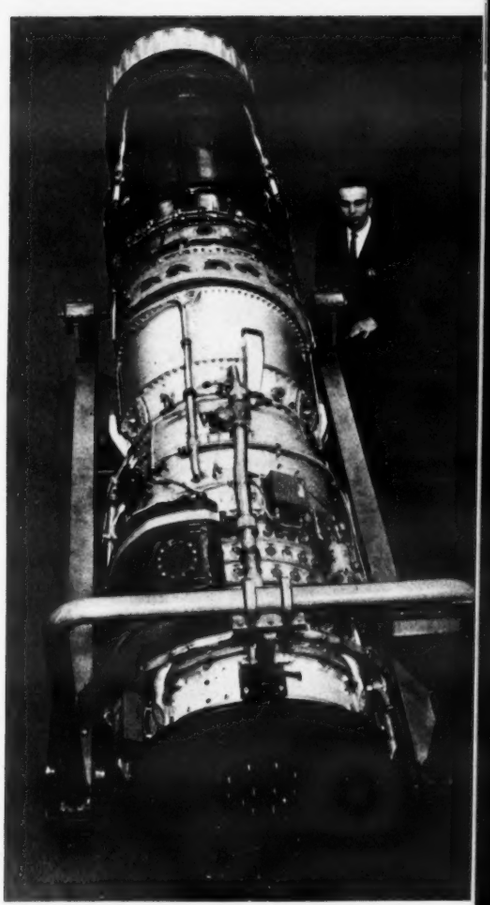
G.E.'s powerful, lightweight J85 turbojet introduces new levels of power and performance. It is a 2000-lb thrust class engine, designed to provide significant dollar savings and performance advantages for missiles, drones, small and medium sized aircraft. The J85 is being flight tested in McDonnell's "Quail" decoy missile, and North American's T-39 utility trainer.

From hover to Mach 3... More power,

FLIGHT POWER SPECTRUM







CJ-805-3

G.E.'s commercial counterpart of the military J79 turbojet. Rated in the 10,000-lb-thrust class, it provides a 4: 1 thrust-to-weight ratio. Now being proved in extensive flight test programs, the CJ-805-3 will power Convair's 880 jetliners. Engine reverser-suppressors were built by G.E. specifically for the -3, produce optimum results with minimum losses.

X220 and CJ-805-21

The first successful U.S. turbofan engine. Designed for near-sonic military aircraft, the X220 combines the proved J79 gas generator with an aft-fan, provides higher thrust at lower SFC. Its commercial version, the CJ-805-21, will power Convair's 600 luxury jetliner. New turbofan growth models being developed assure long service utilization.

J79

The 15,000-lb-thrust class J79 powers six Mach 2 air weapons including the USAF F-104 Starfighter, world's record holder for speed, altitude, and time-to-climb. Other applications : USAF's B58, Navy's F4H, A3J, F11F-1F, and Regulus II. With over 90 % of all U.S. Mach 2 flight time, the J79 has demonstrated ruggedness, reliability.

reliable performance, less weight

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Music in the sky

The CARAVELLE is the quietest aircraft in the world. No vibration : the noise of the jets (mounted at the rear of the fuselage) does not penetrate the cabin. Air France passengers can relax and listen to Mozart in an atmosphere as peaceful as that of a chalet high in the mountains.

Europe at 500 m.p.h.

The CARAVELLE will gradually be introduced into service on Air France's European routes *. Among the first routes to receive the new aircraft will be Paris - Istanbul ; this will place Paris within

1 hr 40 mins flying of Milan
2 hr 00 mins flying of Rome
3 hr 50 mins flying of Athens
5 hr 00 mins flying of Istanbul

* Air France is now carrying out the biggest expansion programme of its history : the " Caravelles " will be followed by four-jet Boeing 707 " Intercontinentals ".

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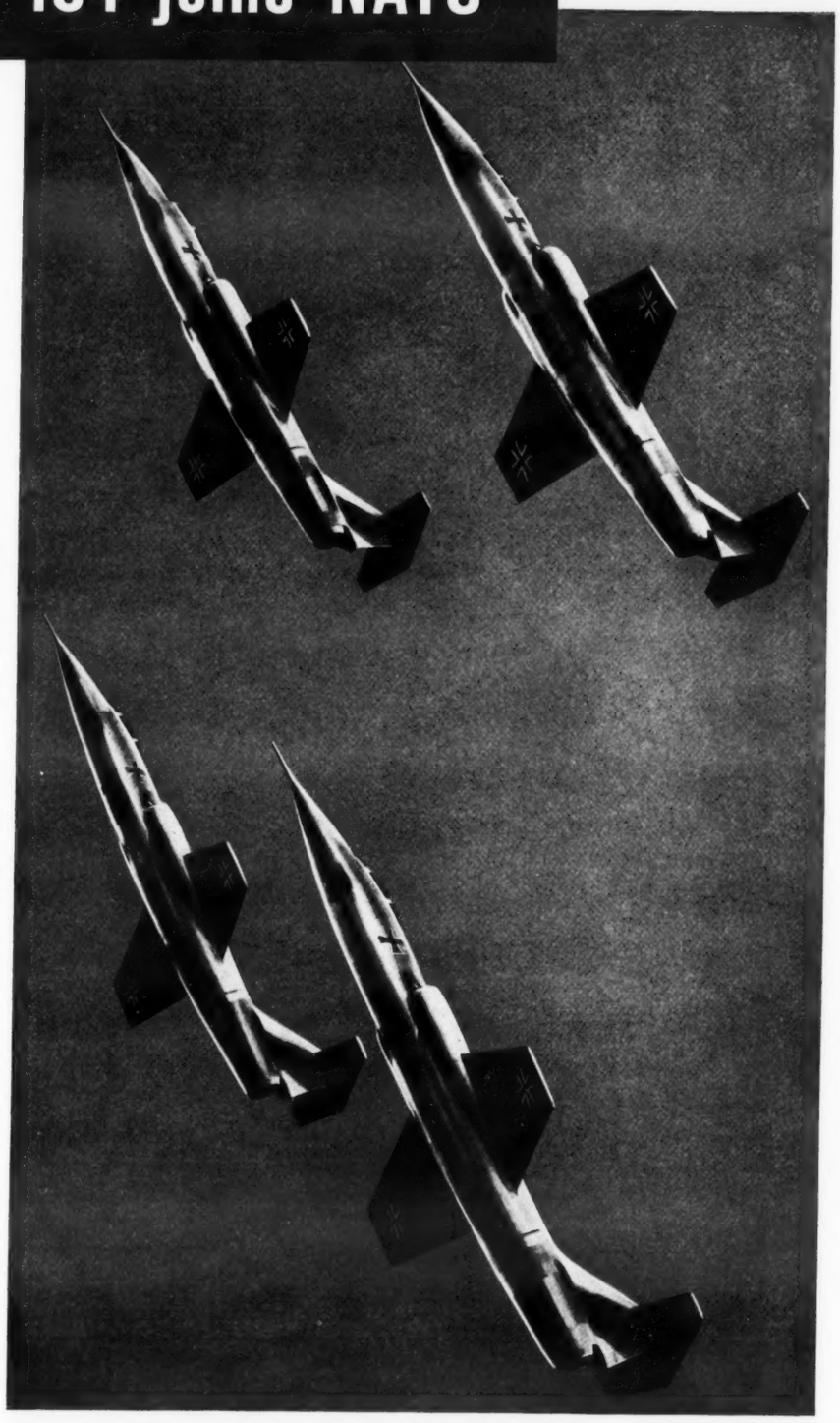
Lockheed's F-104 joins NATO



After a two-year evaluation period during which West German Defense Ministry experts investigated and flight tested airplanes made by 12 competing manufacturers, the plane selected for purchase and manufacture under license in West Germany is Lockheed's famous "missile with a man in it" – the *F-104 Starfighter.*

Never before has a single airplane done so many things so well as the present U. S. Air Force version: Interception, Air Superiority, Ground Support and Reconnaissance – and with so low *proven* maintenance and operating costs.

Holder of the world speed, altitude, and seven time-to-climb records, the current F-104 will be still further developed to meet the specific needs of West Germany and other allies requiring a multi-purpose fighter instead of several separate aircraft for specialized needs. To its already amazing performance is being added all-weather capability for fighter bomber and interceptor missions and also an advanced reconnaissance capability.

The licensing of German manufacturers to produce this advanced version will make it available to West European nations at relatively low cost.

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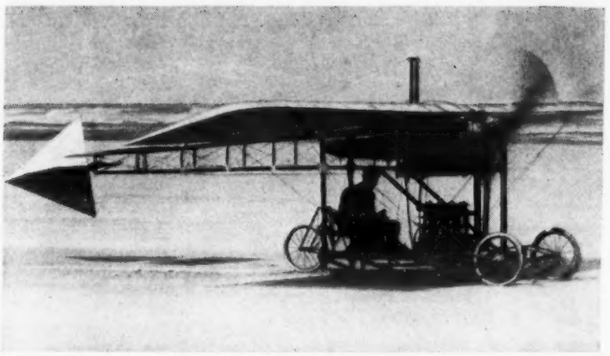

50 years of experience are behind the Blackburn NA.39

1909 Robert Blackburn designed, built and flew his first aircraft at Marske Sands in Yorkshire.

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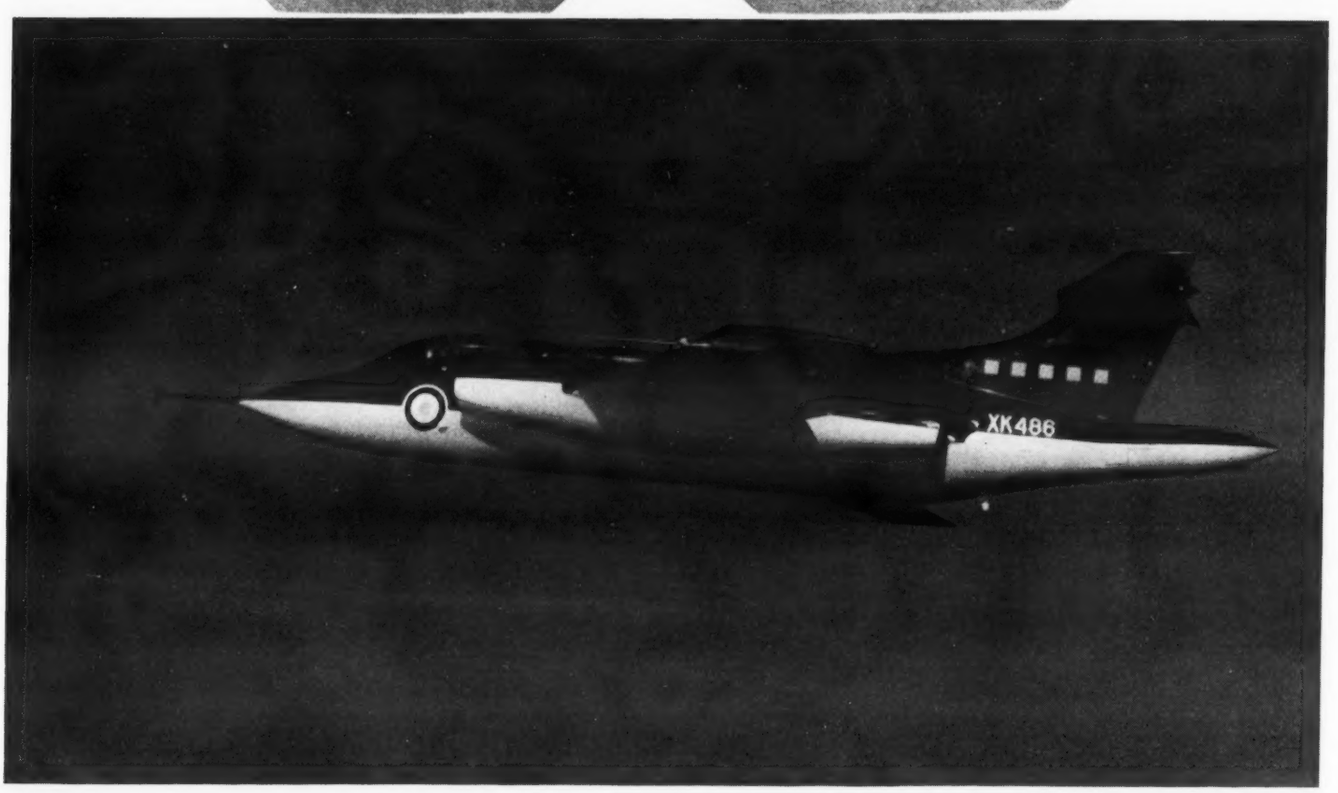
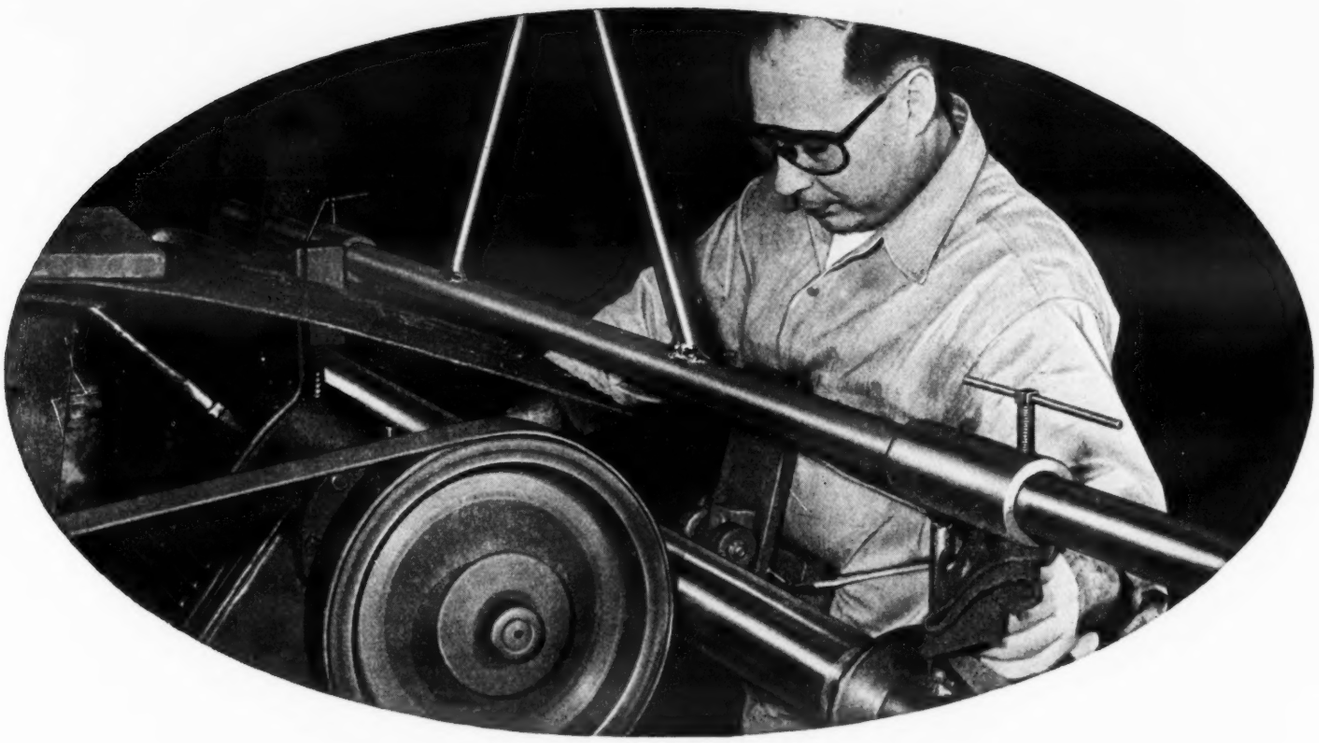


Blackburn and General Aircraft Limited. Brough, Yorkshire, England

OA 128 A



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World's newest, fastest long-range jetliner...

The Boeing 707 Intercontinental, shown above on its first flight, will bring a new order of performance to the air routes of the world when it goes into service later this year.

This new Boeing jetliner has greater range and payload capabilities than any other jet transport. With a range in excess of 5,000 miles with full payload, it is designed to fly nonstop over the longest stages of airline routes. Cruise speed is more than 600 miles per hour.

The Intercontinental is a longer-range sistership of the 707 Stratoliner. Although it is the world's newest long-range jetliner, the Intercontinental is a *proved* aircraft... backed by more than 4½ years

the Boeing 707 INTERCONTINENTAL

of flight testing of the 707 prototype, as well as extensive test programs completed by production 707s. In service since last October, the 707 Stratoliner has been demonstrating the unparalleled passenger-appeal of Boeing jets. Public response, in the words of the operating airline, is "the most enthusiastic to a new airliner in aviation history."

*These airlines have ordered 707 and shorter-range 720 jetliners (*indicates Intercontinental purchasers):*

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BOEING 707 Intercontinental

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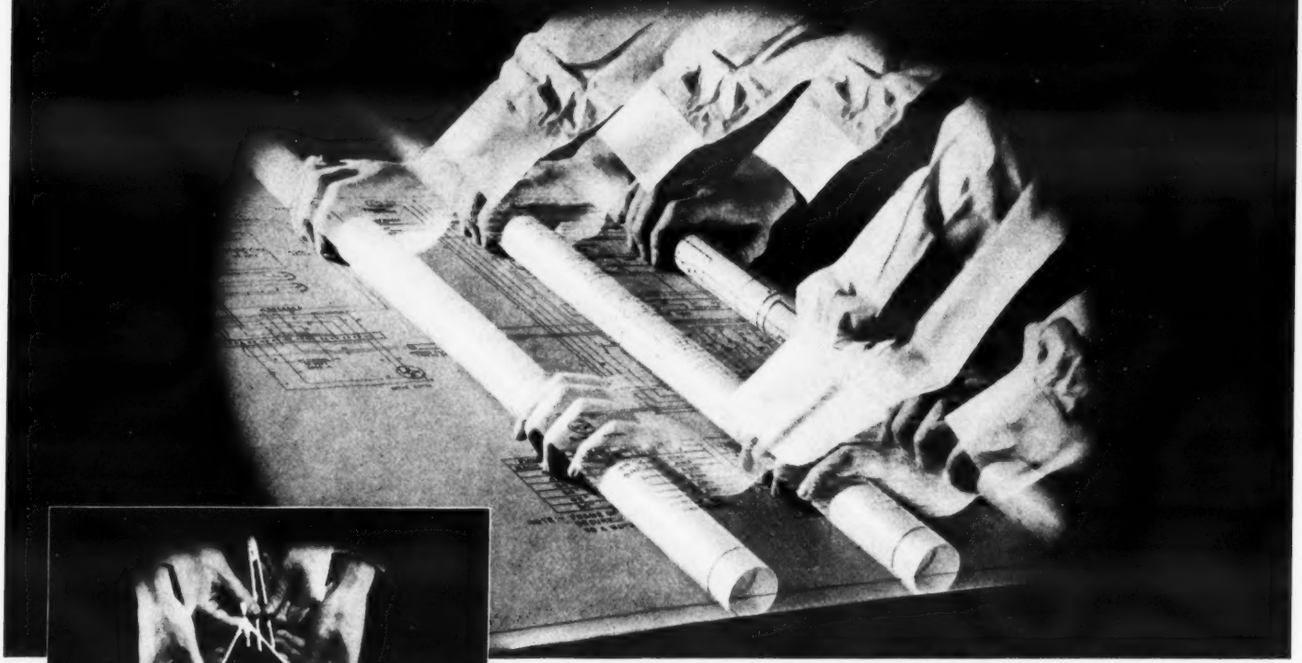

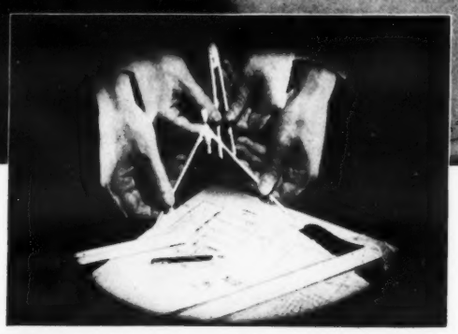

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ALPA on the Airline Strike Question

Replying to the article "The U.S. Airlines Industry Strikes" (Interavia No. 1, 1959, p. 67, etc.), the Air Line Pilots Association has written to our Washington office. Extracts from this letter are reproduced here as the comments are of general interest.

Your recent article on airline strikes, insofar as it concerns airline pilots, wandered from the path of fact and into the byways of speculation in several respects. Of course by now, many of these are academic but the erroneous impression they convey still remains.

We feel that these should be called to your attention, with the hopes that you will take the proper measures to clarify the situation, which as you pointed out in the article may not have been entirely clear at the time of publication.

1. The Pan American pilots were never on strike. The dispute never went beyond mediation, the second step of the Railway Labor Act, and an agreement was culminated while negotiations were in that status.

2. Negotiations under the Railway Labor Act have not been as bad as the article infers. In our own case, we have now negotiated 1,006 agreements in our 28-year history with but five strikes over economic issues. On some airlines we have negotiated every agreement for more than 20 years without going beyond the direct negotiating stage. In the few cases where we have chronic trouble, it does not arise from actual issues incapable of solution but from deliberate programs of the companies to improperly use the procedures of the Railway Labor Act, from weak industrial relations programs, and from consistently poor day by day employee relations and treatment. These, not issues, are what promote strikes. In the case of American for example, it was settled on a basis that contained nothing that had not been negotiated on other airlines long ago.

3. In no case did the ALPA ask a salary of $45,000 for any pilot, contrary to what may have been your impression.

4. There is not and has not been a dispute between the airline pilots and the company nor was any question of jurisdiction involved between the ALPA and the FEIA.

This latter is probably the error that can be the most damaging because it tends to treat a safety problem involving the public interest as a labor matter related to the pilots' economic welfare.

Actually, far from being in disagreement, most of the airlines believe as we do and feel that safety rather than labor implications is involved necessitating adoption of the three pilot basic operational flight crew concept.

In this respect, the Air Line Pilots Association has never advocated that air crews be expanded nor that any crew members be displaced. They have advocated that crews have training which will make them more useful, more efficient, and add an element of greater safety to the performance of flight duties. To this end, they have proposed a basic jet operational flight crew of three persons qualified to fly the airplane and perform flight operation duties.

Some airlines have had this type of crew since 1948. Fourteen of seventeen airlines with equipment requiring the use of more than two crew members now use these basic operational flight crews. It has also been found necessary by a Presidential Fact-Finding Board.

... Radio contacts between the jet, traffic controllers, and company radio facilities, along with the paper work involved in keeping in-flight logs, amount to a full-time job, American said. It pointed out that a New York-Los Angeles nonstop flight of 2,451 miles required a minimum of 81 radio contacts, each lasting about 50 seconds. Shorter route segments present a proportionately more acute problem according to the airline. Between New York and San Francisco via Chicago, contacts were totaled at 101.

In the case of the basic operational flight crew on jet aircraft, the third crew member will be busy with vital flight functions continuously. Specifically, as outlined in the agreement between the company and the pilots, the third member of the basic operational flight team shall perform such duties as are assigned to him by the company and the pilot in command and shall include the following: Assignments in preflight and in-flight planning, including weight and runway computations, temperature and winds aloft studies, etc.; assignments in navigational, communication and air traffic control functions; assignments in systems' monitoring, fuel management, CG control, and efficient and economical management of the flight as required; maintenance of records and required paper work so as to relieve the operating crew currently performing flight duties of such paper work, and relief of any flight crew member as required by routine or emergency conditions and during their absence from the flight deck.

Other airlines feel pretty much the same way. On August 22, the President of Eastern Air Lines said in a public announcement:

"... Compared with propeller-driven aircraft, our new turbojets traveling at much greater speeds, and particularly with the complex air traffic patterns existing today, will require increased concentration on the airmanship elements of flight operations on the part of all three crew members. Thus, in addition to the basic qualification of a flight engineer's license, the jet flight engineer will be further qualified by a familiarity with the basic elements of flight control. This does not in any way change his character as a flight engineer. It simply advances the flight engineer from competency on propeller-driven aircraft to further and different duties which will be required to assist the pilot members of the flight crew in turbojet transport operations. Within the next year and a half, your Company must expand its operating procedures to incorporate this entirely new philosophy of flight. We must be prepared to handle not only today's propeller-driven aircraft but also an entirely new medium of flight, weighing twice as much, traveling twice as fast, at altitudes twice as high."

We feel that the real reasons for the need for basic operational 3-pilot flight crews should be presented in its proper light, and your magazine could perform a valuable service to aviation by doing so.

Air Line Pilots Association

Ed. MODES,
Director Public Relations.

The Editors' Comments

1: *To answer this one we must define the word "strike". According to Nuttall's Standard Dictionary of the English Language, it means: "The act of workmen combining in a refusal to work till the employer concedes what they demand."*

If Pan American World Airways had to put 19 "non-union executives" into the cockpits of their Boeing 707 aircraft in order to fly services which "rank-and-file" pilots refused to operate, then they did so because their "workmen-pilots" combined in a refusal to work.

2: Interavia *in no way maintained that the mediation procedure based on the Railway Labor Act is basically ineffective, but simply stated that negotiations had been unsuccessful in the case under discussion. This is proved by the strikes which have taken place in recent months.*

3: Interavia *did not maintain that ALPA asked for $45,000 per annum as a top salary for pilots, but that this claim had been made by "the pilots". This was widely reported in the press of the world, but was not denied by ALPA.*

4: *The word "dispute" does not appear in* Interavia's *articles on the American troubles. One might point out, however, that though there may not be a dispute in the sense that letters, legal documents and blows have been exchanged, there must be some hard feelings between ALPA and FEIA, otherwise why would George Petty, FEIA's President, cry out: "We are fighting for our lives, and we are going to hold out"?*

To ensure the highest possible degree of objectivity, ALPA's remarks on the question of the "third man" have been given in full, although the Interavia *article in no way suggested that a third pilot was unnecessary.*

We now feel that both sides, airlines and pilots, have had ample opportunity of expressing their views, and that the question of "airline strikes" can be considered as closed... we hope.

INTERNATIONAL MEETINGS AND CONFERENCES

April 7th : Institution of Mechanical Engineers - Leonardo da Vinci Lectures. London.

April 10th : Air Freight Forwarders Association 2nd Annual Meeting. New York.

April 12th-15th : American Association of Airport Executives Annual Convention. Savannah, Ga.

April 12th-16th : International Conference on Fracture. Massachusetts Institute of Technology, Cambridge, Mass.

April 12th-19th : Air Force Association, World Congress of Flight. Las Vegas, Nev.

April 12th-19th : Air Line Pilots Association Annual Air Safety Forum. Las Vegas, Nev.

April 12th-27th : International Fair. Milan.

April 13th : IATA Traffic Conference 2 Agency Sub-Committee. Paris.

April 13th-18th : AGARD Materials Panel. Paris.

April 15th : 10th Anniversary of NATO Celebration within World Congress of Flight. Las Vegas, Nev.

April 15th : ATA Airport Cargo Terminal Facilities Committee. Washington, D.C.

April 15th-24th : Royal Netherlands Engineering Fair. Utrecht.

April 16th-17th : Aeronautical Training Society 17th Annual Meeting. Milwaukee, Wis.

April 17th-18th : 3rd National Conference on Aviation Education. Riverside, Calif.

April 20th-21st : Air Industries and Transport Association of Canada Semi-Annual Meeting. Victoria, B.C.

April 20th-22nd : American Rocket Society Man-in-Space Conference. Hampton, Va.

April 20th-25th : AGARD Structures Panel. Paris.

April 21st-22nd : Spring Technical Conference on Electronic Data Processing, Cincinnati Section of the Institute of Radio Engineers. Cincinnati, Ohio.

April 21st-23rd : 9th Annual Convention, International Airline Navigators Council. New York.

April 21st-24th : Meeting of the Nachrichtentechnische Gesellschaft - " Transistors in High-Frequency Engineering ". Nuremberg.

April 24th : IME Annual Meeting, Annual Report and Accounts for 1958. London.

April 26th-30th : Airport Operators Council 12th Annual Meeting. Portland, Oregon.

April 26th-May 5th : German Air Show 1959 within the Industrial Fair. Hanover.

April 27th-29th : Aero Medical Association 30th Annual Meeting. Los Angeles, Calif.

April 28th : IATA Legal Committee. Rome.

April 28th : ICAO Aeronautical Information Services and Aeronautical Charts Division Meeting. Montreal.

April 28th-30th : ATA Air Traffic Conference Committee Spring Meeting. Washington, D.C.

April 30th-May 1st : American Rocket Society Controllable Satellites Conference. MIT, Cambridge, Mass.

May : AGARD Ionospheric Committee. To be decided.

May 4th : IATA Permanent Working Group on Restricted Articles. Montego Bay, Jamaica.

May 4th-6th : 11th National Aeronautical Electronics Conference, sponsored by Dayton Section of the Institute of Radio Engineers. Dayton, Ohio.

May 4th-14th : IATA 12th Technical Conference. Berkeley, Calif.

May 6th : IATA Air/Sea Working Group. To be decided.

New York Finance Notes

Stock Market Prospects March 1959

BY SCOTT HERSHEY, NEW YORK

It is a rare occasion when foreign convertible debentures are offered in the United States, and therefore one of the most interesting recent market developments was the registration by KLM Royal Dutch Airlines of a proposed $17 million offering of convertible subordinated debentures, due in 1979.

A syndicate headed by Smith, Barney & Company and the First Boston Corporation will offer the securities in the United States and sell a portion of them to certain Dutch banking houses.

The debentures, which are expected to be listed on the New York Stock Exchange and the Amsterdam Stock Exchange, will be convertible into common shares of the company at a single conversion price until maturity, and will be entitled to a yearly sinking fund starting in 1970, which is set to retire all of the debentures by maturity.

Under a United States-Netherlands tax convention, U.S. residents are exempted from the 15 percent withholding tax on dividends paid by Dutch companies. There is no Netherlands withholding tax applicable to the debenture interest payments.

Proceeds of the sale of the debentures will be used to finance acquisition of jet aircraft. The company has made arrangements with three banks to increase an existing revolving credit by $20,000,000.

KLM common stock first was offered in the United States in May 1957 when 250,000 shares were sold to the public at $29 a share. The Dutch Government owns more than 70 percent of KLM stock.

In the registration statement for the debentures, it was disclosed that total operating revenues for 1958 amounted to the equivalent of $129,000,000. Net earnings after a tax reduction in respect to capital investments totaled $3,292,000 or $2.30 a common share outstanding at year-end. This compared with total operating revenues of $130,587,000 in 1957 or $4.12 per common share.

On the manufacturing side of the market, investors are coming to a widening realization that few, if any, major aircraft manufacturers now anticipate 1959 earnings to measure up to 1958 results. Unless important new additions to aircraft procurement programs materialize, the profit potential of civilian jet production threatens to fall far below general projections.

Aircraft issues have been under some pressure, and the outlook is by no means clear or reassuring despite some rises in missile shares in connection with new developments on the Berlin situation.

Both Boeing and Douglas, for example, presumably lacked escalation agreements with the airlines and apparently underestimated the cost of their new commercial jet craft, with the result that earnings will be penalized in the next quarters of 1959. Also, the Justice Department has announced that it would seek from Boeing some $20 million of alleged excess profits on 1952 defense contracts, the outcome of which could set a pattern with respect to refunds of more than $90 million sought from other aircraft companies.

Douglas reported sharply lower earnings in 1958 than in 1957. Net income was $16,847,000 equal to $4.41 a common share, contrasted with $30,665,000 or $8.03 a share in 1957. Net sales, however, rose to a record $1,209,000,000 from $1,091,366,000.

In a jointly signed message to stockholders, Donald W. Douglas, chairman, and Donald W. Douglas, Jr., president, attributed the drop in earnings to these factors : write-offs totaling $67,700,000 on the DC-8 commercial jet-liner program; fewer deliveries on the DC-6 and DC-7 series propeller-driven aircraft ; the protested payment to the Government of $2,025,000 charged against 1958 earnings from the renegotiation of 1954 profits ; and a " profit squeeze " caused by increased labor and material costs.

Significantly, missiles business of Douglas more than doubled in 1958, and orders for missiles at the end of the fiscal year, November 30th, totaled 48 percent of the company's military backlog. Production of missiles, components and ground support equipment rose sharply to $415.6 million from $199.1 million in the previous fiscal year. On a percentage basis, Douglas sales were divided as follows : missiles 34.3 ; military aircraft, 44.4 ; and commercial, 21.3.

The financial news from two other aircraft manufacturers had nothing in it to make their shareholders throw their hats in the air. Fairchild Engine and Airplane reported " serious financial losses " in 1958 and closed their Deer Park, L.I. engine plant for lack of orders. This was on top of the 1957 report when net income fell to $503,331 equal to 17 cents a share, from the 1956 figure of $1,951,484, equal to 64 cents a share.

At the same time, directors of Republic Aviation Corporation cut the common stock dividend in half. The declaration of 25 cents a share for the quarter payable March 23rd, compared with 50 cents distributed in previous quarters. The announcement came after the close of the Stock Exchange. The stock closed at 27 ½, a drop of ⅜ point on the day.

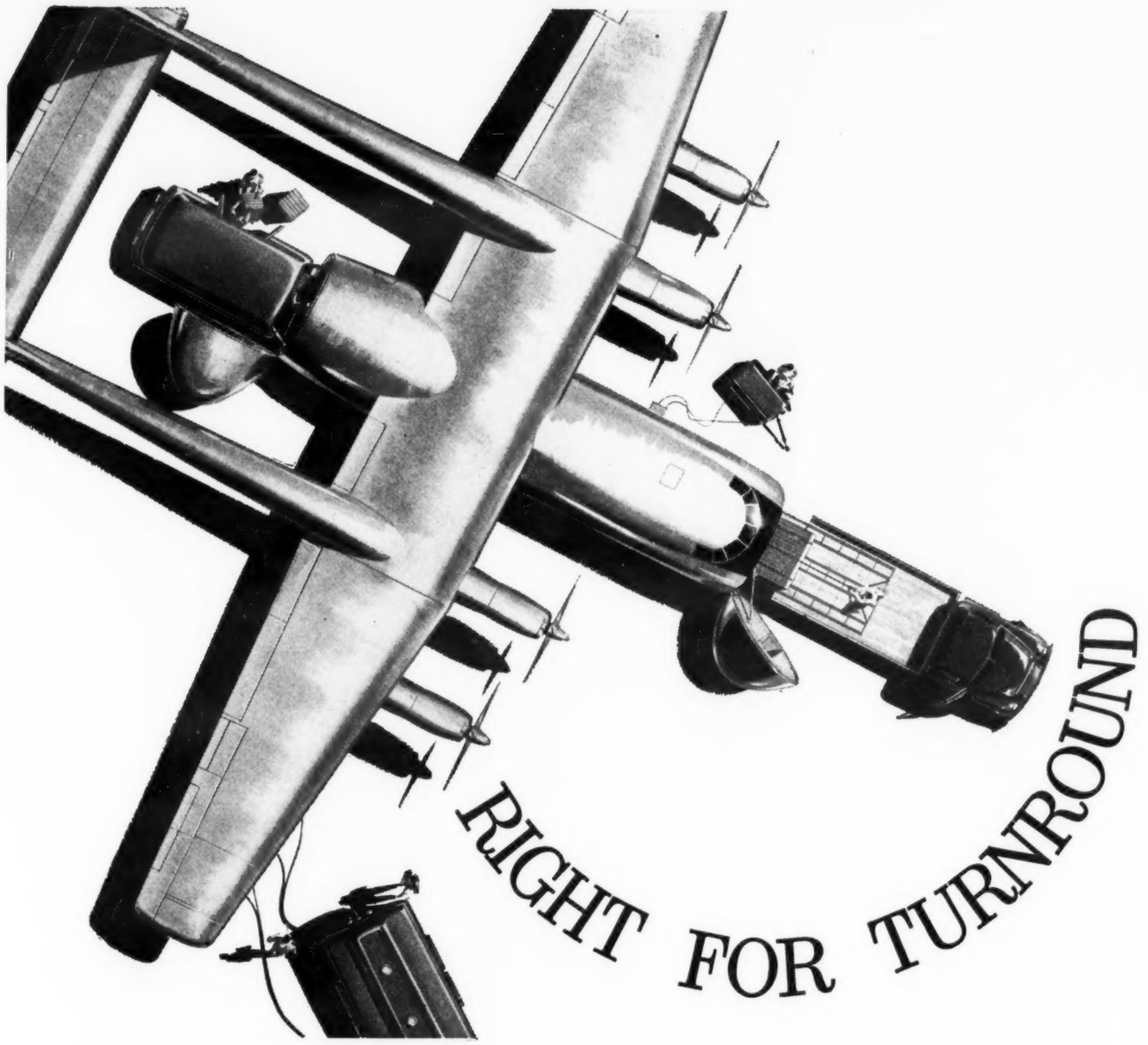
United Aircraft is making substantial outlays of its own money for research and development, a factor which in 1958 contributed to a reduction in earnings. Net income for the year declined to $6.40 a share from $7.96 in 1957, on sales of $ 1,200,427,387 ($1,232,919,313).

There is every indication that in 1959 research and development spending will continue at a substantial rate. United is working on new products for missiles and space vehicles, including an improved lightweight inertial guidance platform to set ballistic missiles on course more accurately than existing systems. The company believes it has good market potential for both military and space projections. Auxiliary power systems for missiles and space vehicles also are under development by United, which is bidding actively to have them incorporated in new Government projects.

Another important project at United is a system to cool cells of infrared ray detecting devices about 400 degrees below zero. The colder the infrared cell, the greater the sensitivity of the detector which can locate heat coming from a considerable distance.

The Pratt & Whitney division also is working on new products including the new J60 (JT-12) lightweight jet engine. Work on this started more than a year ago and it already has passed preliminary tests and has been selected for such planes as the Lockheed *JetStar*, the McDonnell utility jet and a North American Aviation utility jet. The JT-12, which weighs only 450 pounds, is said to develop 3,000 pounds of thrust. It is expected to be ready and fully tested for delivery in 1960.

Pratt & Whitney also has high hopes for its turbofan engine, a version of the J57 which powers the Boeing 707. It is said to produce substantially more power for take-off and climb, while reducing fuel consumption and noise level.



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The less you handle cargo the cheaper the transport operation. This is true particularly of air freight where quick turnround is essential if costs are to be kept to a minimum. With the Argosy (AW650) a loading system is being developed that will enable the huge freight hold to be cleared and filled again in a few minutes. With full-width doors at either end of the fuselage, the load can be discharged at one end while new cargo is being loaded at the other.

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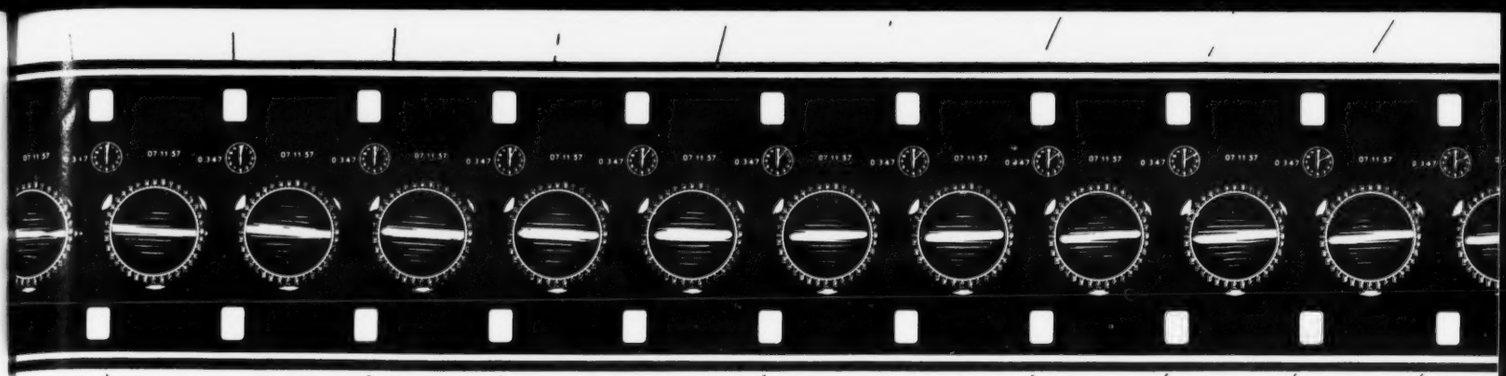

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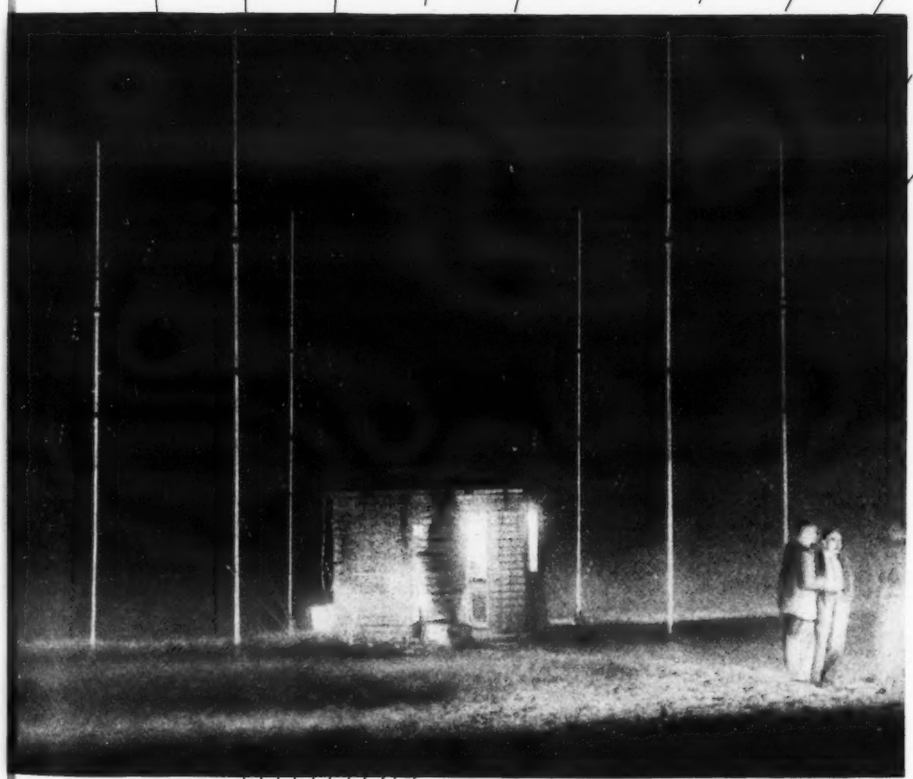

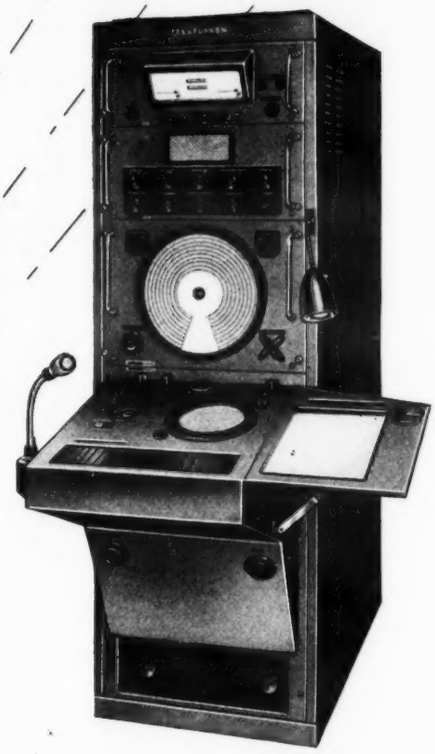

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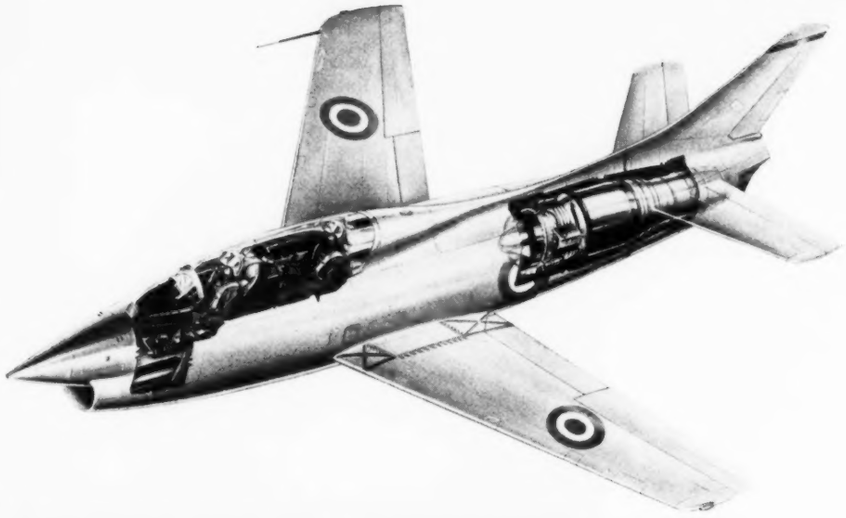

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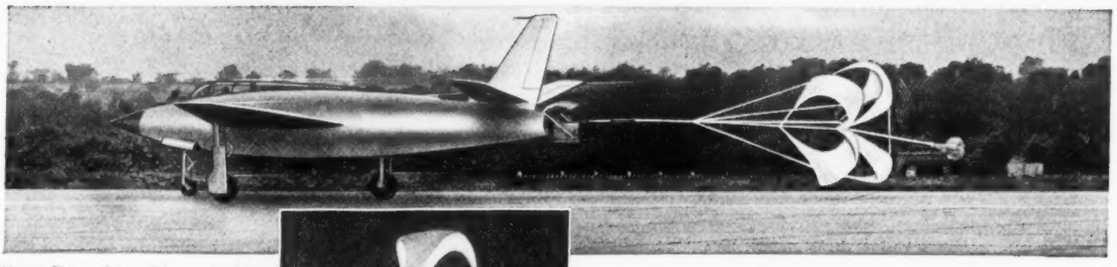
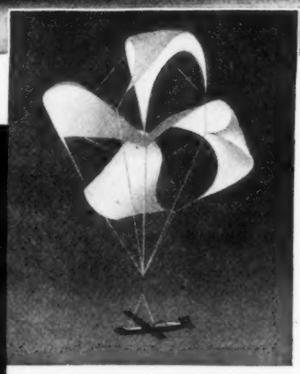
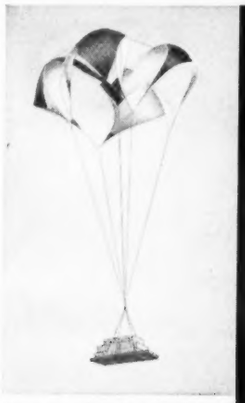


Vortex-Ring drog 'chute brakes landing of jet fighter.



Targets are recovered with ease.



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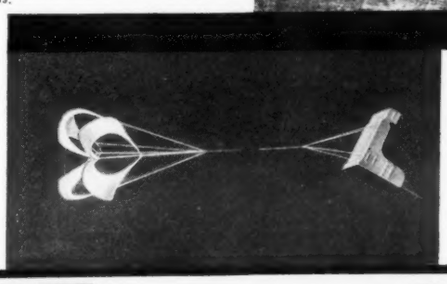

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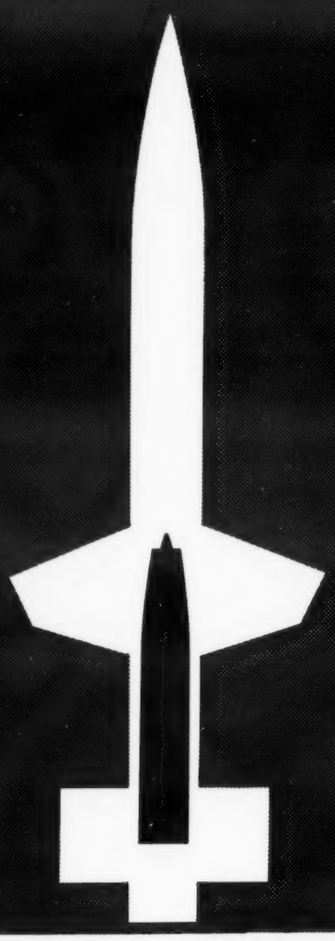

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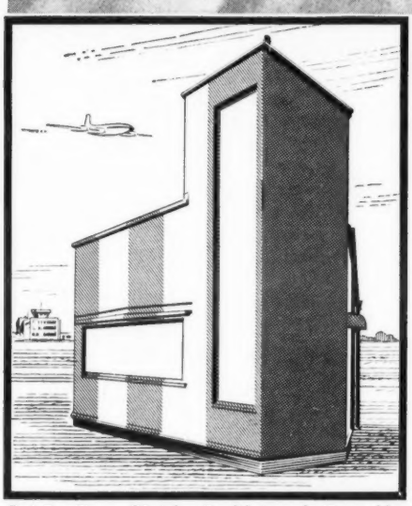

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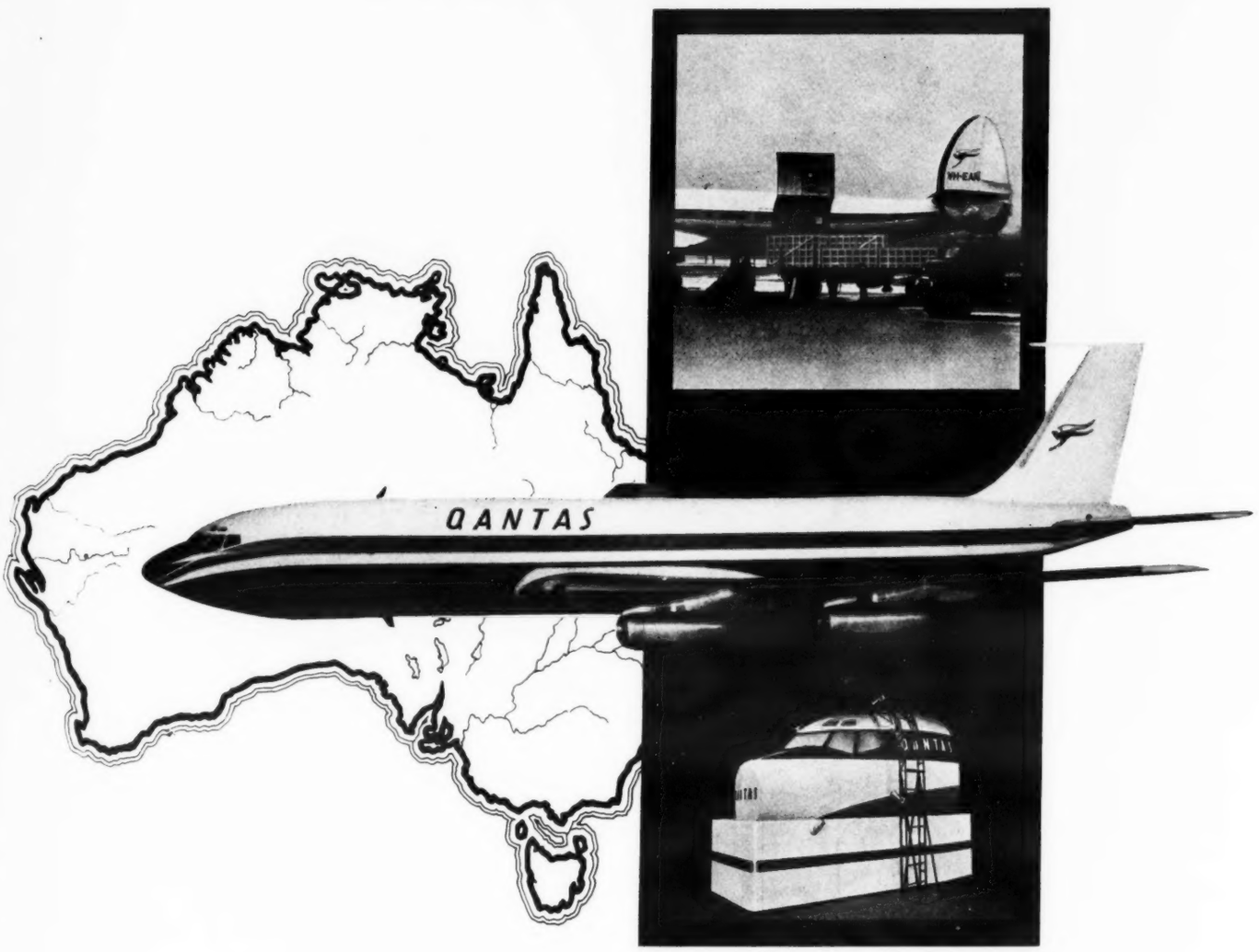

LINK SIMULATOR FLIES TO AUSTRALIA

A Link simulator for the Boeing 707 jetliner was recently air-lifted to Qantas Empire Airways in Sydney, Australia. Two Qantas Super Constellations and two RAAF C-130 aircraft took part in the operation, which marked the first delivery to a non-U.S. flag carrier of a simulator for an American-built jet.

Qantas will make immediate use of the Link jet simulator to train the flight crews that will man the fleet of Boeing 707's it will soon put into service. These crews will receive such thorough and realistic instruction on the ground that transition to the actual aircraft will be swift and natural.

For thirty years a pioneer and leader in electronic flight simulation, Link is the first U.S. firm to have built and delivered simulators for commercial jet aircraft. Qantas is the fourth company to receive delivery of a Link jet simulator. Douglas Aircraft, United and TWA are already training with Link jet simulators, while a number of other domestic and overseas airlines have placed them on order.

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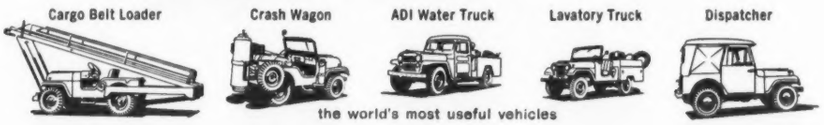

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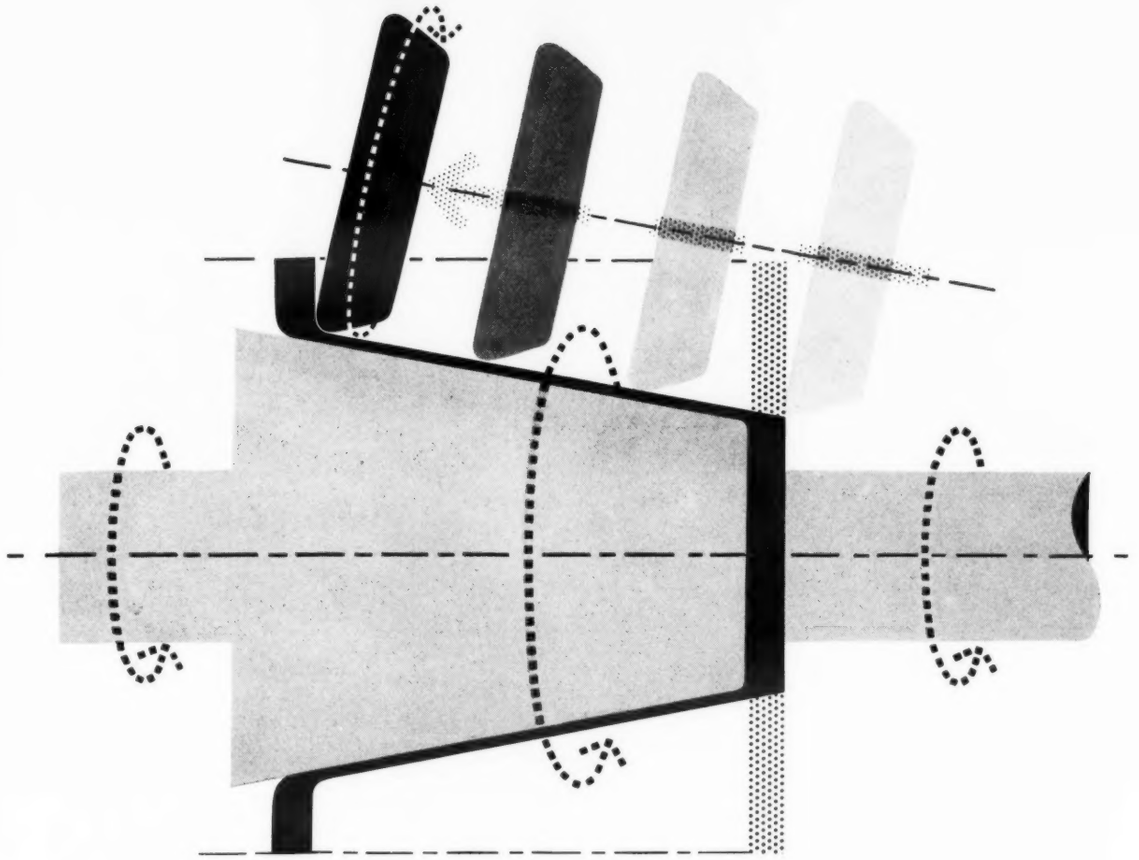

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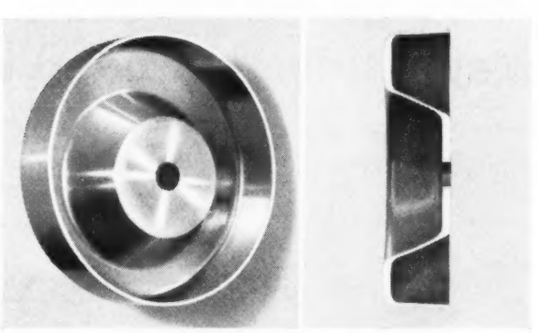
The illustration above shows the flowturning of a simple conical shape from a circular blank. The diameter and the thickness of the centre and flange remain unchanged as pressure from a roller extrudes the material forming a thin wall section in accordance with the shape of the mandrel.

Complex shapes can be formed. The example on the right shows the Nimonic deflector for the Aden gun in the Folland Gnat fighter.

The internal cone is eccentric.



If you have an application for this method of flowturning we should be pleased to investigate and advise.

The illustration is shown by courtesy of Folland Aircraft Limited.

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INTERAVIA

Safety First!

At the end of 1958 the International Air Transport Association's Technical Committee stated that fully automatic approach and landing systems would become a necessity in the near future. The same conclusion had been reached by the technical experts of all the major airlines, after extensive discussions with representatives of industry, research organizations and government authorities during the 11th IATA Technical Conference in Monte Carlo in September 1958. What has been the result?

For the time being a number of problems still remain to be solved before fully automatic landings can be made in commercial operations . . . Perhaps this goal will be reached some day, if efforts are concentrated on improving existing and proven systems rather than on revolutionary new designs.

The specialists gathered at Monte Carlo, however, were agreed that the pilot cannot simply be replaced by "pushbuttons": a fully-automatic approach and landing system which could not be overridden by the pilot in case of necessity must be rejected. Hence the Monte Carlo Technical Conference recommended that *priority should be given to a long-term study programme to handle all questions of approach and landing, cockpit configuration and instrumentation.*

*

Meanwhile another important conference has taken place. *February 14th, 1959 saw the opening of a special conference convened in Montreal by the inter-governmental International Civil Aviation Organization* to discuss the standardization of *short distance navigation aids.* On March 2nd the delegates who had come to Canada for this purpose packed their bags again, without reaching a unanimous decision. Though one of the two proposed short distance navigation systems, namely the American, was given preference in the voting, it did not achieve anything like universal acceptance. The last word has not yet been spoken, and there is likely to be considerable further discussion in the Air Navigation Commission and the ICAO Council, not to mention the debates in Britain's "highly excited" House of Commons.

*

". . . Jet aircraft in commercial service cruise at speeds comparable to that of a pistol bullet . . . and yet must navigate accurately, both in space and in time. The careful observance of flight plans is not only demanded by the traffic control authorities for safety reasons, but is also a major concern of the airlines. Here economic reasons are of no small importance: with the jet's huge fuel appetite, every unnecessary minute's flying, every avoidable detour and every missed rendez-vous over an agreed check point... costs the operator a mint of money . . ." (cf. the article entitled "A Cross-Section of Airborne Electronics" in the present issue).

It is therefore understandable that aircraft captains are expected to have an accurate knowledge of their position at all times and to be able to calculate, and keep to, their ETA above the next reporting point. Understandably, too, crews must have a rapid means of obtaining airport weather information or landing permission, and desire to be able to check for themselves what the weather along the route is like.

*

The Monte Carlo conference in September 1958 was concerned with the safety of approach and landing. The Montreal conference in February 1959, however, was concerned with safety en route—between one check point and another—and with the instrumentation of the cockpit. Short distance navigation is crying out for regulation on an international level, as otherwise there must inevitably be chaos in the jet age in regions of high traffic density such as the "golden triangle" New York–Washington–Chicago, or the London and Paris regions.

It probably does not often happen that the more sensational daily press, either on this side of the Atlantic or on the other, gives a prominent position to articles on purely technical conferences. But this is just what happened with Montreal!

It began with a clear note of warning . . . Had the Argentinian Walter Binaghi, President of the ICAO Council, or H. T. Molgaard, President of the Air Navigation Commission, a premonition of evil to come? It is no common occurrence that such destinguished personalities should feel constrained to appeal to equally distinguished delegates from all over the world for fair play, as if they were referees in the boxing ring . . . *The fight here was around two rival short distance navigation systems, the American VOR/DME and the British Decca, with the supporters of the American system in the majority.*

*

In view of the topical nature of the debate, the present issue is opened by a report on the *February Montreal conference,* in the preparation of which the greatest possible care has been taken to remain objective in view of the tense atmosphere at the conference. A leading Canadian aviation writer, W. A. Wilson, has prepared an eye-witness account of the proceedings. Dr. Ernst Kramar of Standard Elektrik Lorenz, Stuttgart, who also attended the conference and has written for *Interavia* on previous occasions, agreed to put the case objectively, even though his company is directly interested in the more or less victorious VOR/DME system. Finally, a supporter of the defeated Decca group, Howard Capes—whose name is also not unknown to *Interavia* readers—has the opportunity to put forward his views. If the latter appear to reveal a certain bitterness, it must not be forgotten that both parties in Montreal fought with conviction and utmost energy, since the future of the whole short distance navigation system for the next 15 years was at stake.

*

The present issue is devoted to the cockpit of the new aircraft. It describes and illustrates the many different instruments which have emerged from decades of research and development and are designed to provide what passengers and operators alike have every right to expect, namely *safety first!* *EEH*

Three-Week Tug-of-War in Montreal
The Journalist's Eye-Witness Account...

Decisive Step in Short Distance Navigation?

Bitter Anglo-American Dispute mars ICAO choice of navaids

By W. A. Wilson, Montreal

One of aviation's goals is a single, ground-based radio aid to provide for long distance, short distance and approach and landing navigation. A special International Civil Aviation Organization meeting in Montreal in February stated the ideal during one of its few undivided moments and then agreed that the compromises necessary to reach it are not now "technically, operationally or economically feasible".

The meeting was called officially to consider *short range navigation aids*. Its purpose, in reality, was to attempt a settlement of the increasingly bitter contest between Britain's Decca and the Distance Measuring Equipment (Tacan) which forms part of the United States common system, VORTAC. The conference, charged by the British delegation with failing to do its work properly and with approaching the issue with a closed mind, chose DMET, recommending it as the world's standard supplementary navigation aid for areas of high traffic density until 1975. Then, seeming to imply delegates' doubts about the wisdom of their action, the meeting passed without dissent a resolution urging all countries in a position to do so "to develop or continue development of short distance navigation systems based on but not confined to the list of requirements specified by the COM/OPS/RAC Meeting". It voted down a restrictive American amendment and left it up to ICAO's Air Navigation Commission whether to meet one of the United Kingdom's sharpest complaints about the meeting: the failure to include precise data in its list of the characteristics the world requires in its standard navaids, defining in actual figures such points as the degree of accuracy needed.

The Decca-DMET dispute produced a running Anglo-American fight which grew almost unprecedentedly sharp for ICAO, but the secondary question facing the meeting, the extension of the period of protection for the world's basic navigational aid, VOR, as an ICAO standard, was dealt with smoothly. Chosen at a special Radio Technical Division meeting of the Provisional International Civil Aviation Organization in 1946, its protection period as a standard would have expired on January 1, 1966. Delegates agreed that it would continue to serve many areas of low traffic density well into the future.

They set a new protection date of 1975, with only mild British dissent that an improved aid would be needed before that. It was the one decision taken by the meeting which produced general satisfaction. ICAO had begun to find that implementation of VOR was slowing down because of the relatively short period remaining during which States installing VOR stations could rely on them remaining standard.

The future of the Decca-DMET issue remained in considerable doubt when delegates packed their bags and started home after living with it for three weeks. Its official course is clear. The recommendations of the special Communications, Operations, Rules of the Air and Air Traffic Control Division meeting go to ICAO's Air Navigation Commission for study and reference to all of the organization's 73 states, only 36 of which were present at Montreal. The Air Navigation Commission's report on the meeting will come before the ICAO Council, probably in the autumn, when a majority of two-thirds of the 21 members will be necessary for its final adoption as a standard.

The position is clouded, however, by the fact that the DMET decision by the meeting was much farther from unanimity than ICAO likes. The organization recognizes when it is setting world standards that widely disputed decisions are unlikely to be put into effect on any extensive basis. Twenty delegates led by the United States, many of them representing Latin American and Asian states, made up DMET's supporters. Among them also, however, were France, Germany, Belgium and the Netherlands. Four countries opposed the decision in an unusual exhibition of British Commonwealth solidarity: Britain, Canada, Australia and New Zealand. Much more significantly, twelve nations abstained on the vote and four countries—Britain, Canada, Mexico and Japan—reserved their future positions on the issue, including implementation.

Two factors overshadowed the vote. One was the known American decision to go ahead with installation of its VORTAC system after a long internal dispute between civil aviation interests and the Department of Defense. Most delegates felt that little they did would affect this established American position. The British position was less definite but an indication of it was provided when the Ministry of Transport and Civil Aviation announced during the course of the meeting that it will establish special jet airways for aircraft equipped with Decca. The practical pressure on

Walter Binaghi, President of the ICAO Council, opened the Montreal Conference with an appeal to delegates to remain objective. Next to President Binaghi: (left) *ICAO Secretary General Carl Ljungberg;* (right) *H. R. Adam* of the ICAO Secretariat; (far right) *J. W. Stone*, head of the Australian delegation and Chairman of the Conference.

any state with extensive international aviation interests, except perhaps the United States because of its size and the extent of its commercial flying, is considerable to adhere to any important ICAO standard. The conclusion could be drawn from the MTCA announcement, however, that Britain was at least prepared to establish a dual system offering advantages to Decca-equipped airplanes, including BOAC's *Comet 4s*, over foreign aircraft using DMET.

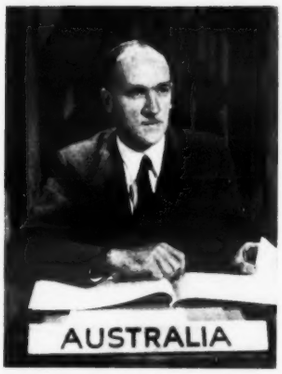
Decca was put forward for consideration at the beginning of the meeting in its advanced Mark 10 form but in the end the head of the British delegation, Group Captain J. B. Veal, refused to propose it formally for adoption. He said bluntly that the attitude of the meeting had shown that Decca would not be considered on its merits and condemned the way in which the work of the conference had been done. His strongest criticism was of the meeting's refusal to permit the inclusion of precise data in the list of operational requirements. He had been supported in committees in this view by Australia's chief delegate, James Stone. Mr. Stone, however, was the extremely able and firm chairman of the conference's plenary sessions. At these sessions, which he kept under remarkably strict control, he could not act as his country's representative. Observers were inclined to feel that on this score the British complaints were largely justified since there had been conspicuous and generally successful efforts in the committees to prevent the inclusion of any requirement that it appeared Decca could meet better than DMET.

Group Captain Veal selected one of these points for an obvious demonstration. The British delegation had originally attempted to have included in the statement of requirements an item that "the system should require no regular air calibration checks". This would have suited British claims for Decca considerably better than American statements on behalf of DMET. It was voted down. Later the British put it forward again in milder form, this time reading that the system "should require the minimum of air calibration checks". The American led majority defeated it again, leading Group Captain Veal to comment that, since it was an obviously desirable requirement viewed objectively, it was inconceivable to him that governmental representatives could vote against something involving an economy.

Group Captain Veal later told the meeting that it had failed to do its work properly and enumerated the shortcomings as he saw them as: 1. the failure to include precise data on requirements; 2. a refusal to evaluate objectively the systems against the requirements; 3. disregard for expert advice, a reference to support for hyperbolic aids of the Decca type from the International Federation of Air Line Pilots' Associations; and, 4. firm adherance to positions adopted before the meeting started.

Observers of the meeting felt that, while there was a basis for the British complaints, the United Kingdom overlooked the fact that many delegates, although not all of them, had made up their minds through advance evaluations of the systems. Significantly, while 16 states refused to support DMET, no delegation except the British had come out in Decca's favor while it was still before the conference. Several had said in strong words that neither DMET nor Decca met the world's needs as an aid for high traffic density areas. It was, however, clear from the early stages of the meeting that the United States headed a strong enough voting *bloc*, many of them underdeveloped states which could hardly have an intense interest in high density traffic problems, to prevent decisions unfavorable to DMET.

Opponents in the battle of words: left, *J. H. Tippets*, director of the Federal Aviation Agency's Office of Air Navigation Facilities and leader of the U.S. delegation; right, *Group Captain J. B. Veal*, of the Ministry of Transport and Civil Aviation's Navigational Services and head of the British delegation.



James W. Stone, chief Australian delegate and elected Chairman of the Conference, conducted the plenary sessions with remarkable objectivity.

Two of the groups most keenly interested in the issue and represented by observers took diametrically opposite sides. They were the International Air Transport Association, so strongly in favor of DMET that its observer, Paul Besson of Air France, became embroiled in his own dispute with the British, and IFALPA, represented by Capt. W. M. Masland, a senior Pan American pilot and a vice-president of the pilots' group. IFALPA takes no position on specific equipment but strongly favored hyperbolic aids of the Decca type and admitted that of those in existence Decca came closest to meeting its requirements.

IATA's position was contained in a working paper, but Mr. Besson added to it at a press conference where he produced figures on Decca reliability which he claimed represented airline experience. These, he said, showed that 30 to 40 per cent of the time the Decca equipment concerned produced no information at all and worked well only 30 per cent of the time. This was widely reported in the press, and at a subsequent conference meeting Mr. Besson said he wished to draw attention to the fact that IATA's position was outlined in its working paper and that this contained no reference to reliability figures. An IATA official had commented in advance of Mr. Besson's statement that "we have to apologize to the British", and members of the British delegation said they had insisted on an apology. Subsequently, however, an IATA spokesman informally denied that an apology was intended.

The large American delegation, operating with the support of a powerful bloc of delegates which voted with them on most issues and on all major ones, became seriously disturbed only three times during the meeting.

Near the end of the conference, J. H. Tippets, the head of the U.S. delegation, read a lengthy statement disputing Group Capt. Veal's criticism of the meeting, defending DMET and criticising Decca. Earlier he had objected to British references to an American official on the delegation, Bert Denicke of the Federal Aviation Agency. Mr. Denicke had delivered a talk on an experiment at New York, now in its early phases, in which Decca is being used by the helicopters of New York Airways. His talk included a figure of 83 per cent for Decca's reliability during December. Mr. Denicke said that he was giving the talk "by direction" and admitted that figures based on early stages leave something to be desired. Group Capt. Veal subsequently challenged parts of his talk, commenting that he did not envy the invidious position of a technical man presenting conclusions based on an incomplete experiment and citing the 98.4 per cent reliability achieved with Decca used by Silver City Airways in Britain. Mr. Tippets later objected that the references to Mr. Denicke cast reflections on his integrity and drew the smiling British reply that the words had been selected with care.

Capt. Masland, however, caused the American delegation its greatest concern through a vivid presentation of the complexities and difficulties facing airline pilots approaching or leaving New York City. He described crowded airways and holding patterns based on VOR and non-directional beacons and described an actual departure last summer of four airliners, one of which he had piloted. Two had been flown into the paths of oncoming traffic under radar control, and Capt. Masland admitted that the communications system involved contained no fail-safe provisions and that a radio failure would have created "a problem". Mr. Tippets intervened at once to dispute the impression he felt might have been created that New York is not safe. He insisted that it is, in fact, safe although it has air traffic control problems in common with all other major terminal areas including London. It was clear, however, that Capt. Masland had made a considerable impression on delegations, and one British representative commented dryly that "It is quite wrong to introduce a note of reality into conferences like this".

The conference began with warnings from Walter Binaghi, President of ICAO's Council, and H. T. Molgaard, President of its Air Navigation Commission. Mr. Binaghi warned that an element of emotion had already entered the issue and appealed for objective consideration of navigation problems. Mr. Molgaard urged delegates not to turn the meeting into a voting contest and warned that problems arise implementing ICAO decisions when they are not based on a considerable majority.

In the end, 20 votes for DMET, four against, 12 abstentions and four statements reserving national positions fell considerably short of the sort of results Mr. Molgaard had urged the conference to seek.

A Supporter of the American System Writes:

VOR/DME Becomes ICAO Standard until 1975

By Dr. E. Kramar, Standard Elektrik Lorenz AG., Stuttgart

An important, and long-awaited, decision regarding short distance navigation aids was made on February 25th, 1959.

Of the 36 nations represented at the ICAO meeting in Montreal, 20 voted for recognition of the U.S.-developed VOR/DMET system as ICAO standard until 1975, only four countries voted against it, and 12 abstained. The Decca system put forward by Britain's representatives was not accepted, despite strong support by the Commonwealth delegations and despite a large number of very efficiently organized demonstration flights in a *Comet 2*, some of them over the North Atlantic to show the combination of Decca with the long distance Dectra system. What were the reasons behind the Montreal decision, which will undoubtedly have far-reaching repercussions?

Of the eight systems of short distance navigation aids originally put forward for discussion, only two had reached a technical stage sufficiently advanced to qualify them for serious consideration as ICAO standards, namely VOR/DMET and Decca. Technical details of these systems, which have been in proven operation for many years, and of their many improvements have been given repeatedly in these pages. The original DME system, developed by the United States, had never come into service, despite its inclusion as a recommended practice in ICAO Annex 10. Why? Because in the United States itself the RTCA programme* called for a joint civil-military short distance system, and because no information on the distance measuring element of TACAN as a supplement to the civil VOR could be published until the whole military TACAN system came off the secret list, some two years ago.

The U.S. proposal at Montreal was that the old DME specifications in Annex 10 should be replaced by the new specifications for DMET (Tacan-DME) and that VOR, the existing ICAO standard, should be supplemented by DMET and approved as ICAO standard for short distance navigation. On the other side, the British delegation proposed that the Decca system, used in conjunction with VOR, should be declared a standard for the same purpose. As already stated, the American proposal was accepted. The old DME specifications have been withdrawn and replaced by DMET specifications, and the whole system now bears the designation VOR/DME, with the letter T omitted.

First a word on the two basically different systems which the two parties put forward as an aid in the performance of the same task, namely to provide the pilot on a continental flight with the required navigation data in the most telling fashion and to enable him in areas of high traffic density, particularly in the terminal areas around large airports, to carry out the procedures ordered by Air Traffic Control as accurately as possible.

To achieve this end the one party uses instrument readings showing direction and distance from or to a fixed point, of the kind which are compatible with the natural flying instinct and the training of the pilot; the other party uses map presentation—Flight Log—which can be compared to an automatic version of maritime navigation. The one side stresses that in en route flying it is not necessary to have precise knowledge of momentary position, but only of direction to and distance from a fixed point; stacking and approach manoeuvres can also be carried out satisfactorily with these data, it is claimed; pictorial presentation—which can also be provided with the VOR/DME system without a computer—is desirable in certain cases, but not absolutely essential . . . The other side argues that only the Flight Log enables an aircraft to fly on any desired track and hence meets the demand for flexibility. It alone, say its sponsors, makes it possible to fly any course or holding circuit, to move airways, to modify approach and departure procedures without difficulty and, by means of appropriate distortion of the map scales, to obtain such a degree of discrimination that two parallel tracks can be authorized at the same altitude within the width of a single airway (lateral separation).

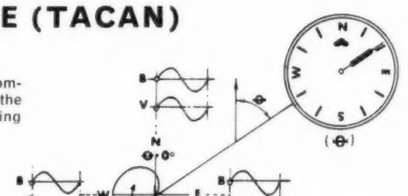
* RTCA: Radio Technical Commission for Aeronautics; cf. "On the Way to All-Weather Flying: RTCA Programme" in *Interavia* No. 7, 1948, p. 366, etc.

The Decca system does undoubtedly have greater accuracy, so that it offers the advantage of lateral separation briefly outlined above. But this accuracy is obtained at the expense of ambiguity in readings which can be eliminated only by complicated methods, such as automatic lane identification in the Mark 10 system. This affects operating reliability and makes it very difficult to check correct functioning. The simplicity of the VOR/DME system is in striking contrast. It must, however, be admitted that angular accuracy in VOR is limited, on the one hand because of the absence of ambiguity over the whole 360 degrees, and on the other because of siting difficulties. However, these considerable errors can be eliminated by high-accuracy equipment, such as VOR-Doppler systems (or VORAC; Ed.).

The two systems also differ very considerably in range: on the one hand there is VHF and UHF, with the disadvantage of line of sight range, but the advantage of complete immunity to atmospheric interference; on the other hand LF with very much greater range, but limited by the effect of space

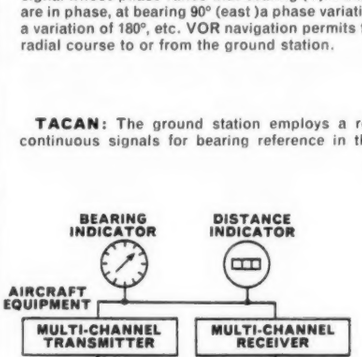
VOR and DME (TACAN)

The VOR/DMET system combines VOR equipment with the TACAN distance measuring equipment.



VOR: The bearing Θ to a VOR ground station is determined in the aircraft by automatic phase comparison of a non-directional reference signal (B) and a rotated signal whose phase varies with bearing (V). At a bearing of 360° (north) both signals are in phase, at bearing 90° (east)a phase variation of 90° is apparent, at 180° (south) a variation of 180°, etc. VOR navigation permits the aircraft to maintain any required radial course to or from the ground station.

TACAN: The ground station employs a rotating beam antenna to transmit continuous signals for bearing reference in the aircraft and, as required, reply signals for distance measuring (polar coordinate navigation). Each second 3,600 pairs of pulses are transmitted, of which 900 are reserved for reference groups for coarse and fine bearing, while the remaining 2,700 are random in time and include synchronized replies to distance interrogation.



waves at a distance of some 200 nautical miles from the master station; radiation is independent of altitude, and hence suitable for helicopter navigation; the effect of atmospheric interference can be largely eliminated by suitable antenna design with amplifiers.

In judging the value of radio navigation aids the following questions play an important role: availability of frequencies for world-wide use, cost of the airborne and ground installations, siting requirements for the ground equipment, etc.

One particularly important point is whether the system can be used by all categories of aircraft, as not only the big airliners, but also the "little man" must be thought of. In this respect VOR/DME offers the advantage of being a "building block" system and can be fitted progressively. Nobody contests that VOR alone renders valuable services for en route navigation. When supplemented with DME, this navigation system will go a long way to meeting operational requirements for many years to come. The introduction of Decca as a supplementary installation to VOR would combine two basically different systems which have nothing in common and would require two sets of airborne and ground equipment. The same reasoning applies to the desire to combine long distance, short distance and landing navigation. Here it is not the physical possibilities that are decisive, but obviously only the interests of the users: the number of pilots who fly continental stages and are also interested in landing navigation is undoubtedly vastly greater than the number of intercontinental pilots. Another factor is that VOR and ILS airborne equipment working in the same frequency band —and generally combined with a communications unit—is now obtainable in a wide price range. On the other hand, even when simplified airborne equipment is available, the Decca system requires a Flight Log (flying by Decometers is possible only in special cases), in other words an equipment whose cost cannot be compared to that of the VOR instruments and which is very difficult to combine with landing navigation.

The present article can obviously give only a selection of the arguments facing Committee B at Montreal, which had been charged by the assembly with examining the main characteristics of the two systems. Full details can be found in Document WP 37, which covers 95 pages and will be published as an appendix to the conference report.

Committee A's task was to study the operational requirements which ICAO must lay down for short distance navigation aids. The objection is now being raised that the 40-point report of this Committee (Document WP 41) is restricted to a discussion of the advantages and limitations of the two rival systems and ignores future development. By contrast, in the voting on VOR/DME, several States proposed that development of a new system to meet all the requirements likely to arise after 1975 be recommended.

Does this mean that the ICAO decision was premature? Certainly not. Any further delay would have prolonged for years the almost intolerable conditions existing today in short distance navigation aids. Under the pressure of events States would have been obliged to make heavy investments in an effort to obtain at any rate a temporary improvement in the situation. And many small countries might well have hesitated to do anything at all, for fear of putting their money into some system which would soon become outdated. But quite apart from all these considerations, it is probably in the nature of things that operational demands will always be higher than the engineers can meet at an economic outlay. Technical advances will never be able to keep pace with requirements.

The most difficult task, however, awaits the leading men who must weigh the pros and cons of what is technically and economically attainable and decide upon a compromise which can be accepted for a number of years. The "breathing space" of one to two decades afforded by the ICAO decision will not only enable the air traffic control network to be systematically expanded under financially acceptable conditions, but will also give manufacturers time to work on their ideas at leisure, constantly improving and thoroughly testing their equipment. It is from this standpoint that we must judge a proposal put forward by the United States, but unfortunately rejected, namely that any new system to be considered as a possible replacement for the now standard VOR/DME must represent a real step forward.

Extracts from the Opening Statement by Group Captain J. B. Veal, United Kingdom Delegation

...Having regard to the time necessary for implementation of a new navigational system and the period necessary to ensure that the requirement has an economic life we need, I suggest, to think in terms of 15 years or so.

From the airway, or air route aspect the web of criss-cross routes will become more dense and, from the air traffic control point of view, more difficult to handle. Whenever possible, therefore, route structures should be so designed that the minimum of ATC coordination is required to ensure the safety of traffic. This concept calls for a uni-directional, probably parallel airways system with its obvious problems of the accuracy requirements of the navigation system and the method of display of navigation information which we must consider.

If we are to provide a sound basis for air route development we must choose an aid which conserves airspace or, to put it another way, an aid which is not, in itself, the limiting factor of the capacity of controlled airspace. If an aid is adopted which, having regard to the accuracy with which aircraft can be flown, enables small lateral separations to be employed between adjacent aircraft, we shall have achieved our aim.

Within the period I have postulated, we shall see the range of airspeeds widen. The latest civil jet aircraft already approach the speed of sound. The need for pilots to know precisely and quickly where an aircraft is becomes greater as speed increases.

...Towards the other end of the speed range the use of rotary wing aircraft and jet and propeller lifted and propelled STOL and VTOL aircraft may be expected. In addition to increasing the overall traffic they will complicate the traffic patterns, as they will no doubt operate along sections of main trunk routes as well as elsewhere. Just as local service transport on the roads and railways needs to be segregated from express traffic, so must such traffic be separated in the air, for each class of traffic impedes the efficient progress of the other when operated along common road, rail or air tracks...

A Supporter of the British System Writes:

Montreal—and After

By Howard Capes, London

"I'll be Judge, I'll be Jury," said cunning old Fury. "I'll try the whole cause and condemn you to death." *Lewis Carroll*

So the inevitable decision has been taken at Montreal. The fact that DMET has been added as a supplementary standard to VOR should not come as a surprise to anybody. Nevertheless, it is as well to understand clearly what the issues were, how the decision was reached, and what the effects of that decision may be.

At Montreal there was never the slightest difference of opinion on the use of VOR, and that the protection date for this equipment should be extended to 1975 was quite as it should be; VOR as a navigational aid for low density areas has its application.

The fact that DMET was accepted as a supplementary standard would not give cause for much comment but for certain disquieting factors which became apparent during the course of the debates: in 1946 VOR/DME was adopted as the international standard navigation system; it is well known that the DME as envisaged at that time was never engineered and the Americans changed horses in mid-stream in an attempt to install the distance measuring element of TACAN to replace the long-awaited civil equipment. However, in the meantime the condition of civil aviation has changed almost beyond recognition, and to the casual observer it might seem a little strange that the opportunity was not taken to amend the requirement to take into account the increase of aircraft density and performance.

The futility of adding fresh hardware to an obsolete system in a fruitless effort to make it work will inevitably have repercussions on the growth and progress of civil aviation. VOR is not only far less accurate than its sponsors originally predicted, it is also too inaccurate and too inflexible to permit the lateral separation which is an immediate operational requirement for jet aircraft both en route and in terminal areas. The addition of DMET will do nothing to add to the fundamental lack of accuracy of the joint system.

The lack of objectivity of this Montreal meeting has already received wide comment from the world's press and requires no further elaboration here; the refusal of the American *bloc* to accept any quantitative or qualitative requirements that could not be met by DMET will long be remembered, but it would seem from the special COM/OPS/RAC acts meeting that, as the voting is at present constituted in the International Civil Aviation Organization, whatever is proposed by the United States will be accepted, what is alien to American commercial interests will stand little chance of acceptance.

In commercial jets almost all antennas are buried, to reduce drag. The only external antennas on this Boeing 707-320 *Intercontinental* are the HF sting antenna (on the fin) and two fin-type VHF antennas above and below the 6th window.

Airborne Electronics for Jet Airliners

Jet aircraft in commercial service cruise at speeds comparable to that of a pistol bullet... and yet must navigate accurately, both in space and in time. The careful observance of flight plans is not only demanded by the traffic control authorities for safety reasons, but is also a major concern of the airlines. Here economic reasons are of no small importance: with the jet's huge fuel appetite, every unnecessary minute's flying, every avoidable detour and every missed rendez-vous over an agreed check point, often resulting in a loss of priority, costs the operator a mint of money.

Understandably enough, then, the jet aircraft captain is required to have an accurate knowledge of his position at all times and to be able to calculate, and keep to, his ETA above the next reporting point. Understandably too, crews must have a rapid means of receiving airport weather information, permission to land and other details, and desire to be able to check for themselves what the weather along the route is like.

*

The need for immediate **knowledge of position** at all times makes the presence of the following equipment aboard the aircraft indispensable:

Cockpit of the Douglas DC-8: The eleven main instruments in front of the captain's control column are (in this version): *top row, left to right,* airspeed indicator with angle-of-attack indicator (Kollsman), Gyrosyn Compass Indicator (Sperry), Horizon Flight Director Indicator (Sperry), clock. *Second row, left to right,* Machmeter, drum altimeter (Kollsman), Pictorial Deviation Indicator (Sperry; replaces cross-pointer instrument), rate-of-climb indicator, VOR radio magnetic indicator. *Bottom:* turn-and-bank indicator and indicator for airbrakes. Behind the engine control pedestal (centre of picture) is the daylight screen for the airborne radar; above the latter are four sets of engine instruments and thermometers.

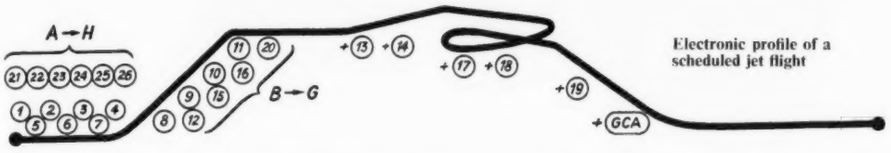
Cockpit of the Sud-Aviation SE.210 Caravelle: In the centre, two sets of engine instruments. In front of each pilot's seat are the following main instruments (outlined in white): airspeed indicator (top left in each case) and turn-and-bank indicator (below), attitude indicator (centre top) and master compass indicator (below), rate-of-climb indicator and altimeter.

a) Highly accurate and reliable remote compass systems: gyro-plus-magnetic compass systems in multiple installation, to enable cross checks to be made. In order to obtain compass references which are completely free from oscillations, the primary signals for the compass indicator are now always taken from a directional gyro (naturally with minimum random drift) and the gyro is electronically "slaved" by means of the output signals from a magnetic flux valve. For flights over the Arctic, correction by means of the flux valve is discarded in favour of an automatic slaving system which compensates for the influence of the earth's rotation on the directional gyro reading (15 degrees per hour times the sine of the latitude) and permits of grid navigation.

b) Accurate, fast-working, simply operated radio navigation equipment: illustrated by the impressive group of radio navigation equipment in the accompanying table (Nos. 8 to 14, also 17 and 19), also the article on the ICAO navigation conference elsewhere in this issue. All that need be added is that some of the radio navigation equipment still in use today, e.g., ADF and Loran receivers, are merely "stopgaps," which will remain in service only until the more modern systems of ground navigation radio beacons have been extended to a satisfactory extent.

c) Autonavigators and/or Flight Log: For high-speed long-range aircraft these navigation aids form the indispensable *final link in the chain of equipment required for instantaneous position finding*. They alone can tell the pilot really where he *is* at any given moment—not where he was a few moments before—although it must also be admitted that the equipments listed under a) and b) are required to ensure the accurate setting of the autonavigators and/or Flight Log. There are today three different kinds of autonavigator: 1. automatic dead reckoners (with a maximum position error smaller than 10 percent of the distance travelled); 2. Doppler radar systems (with a maximum position error of less than 3 percent of the distance travelled); 3. inertial navigation systems (with a maximum position error of less than 6 nautical miles per hour flown)*. The only known equipment giving a pictorial presentation of the track flown is

* These accuracy figures are taken from *H. Giesecke:* "Air Traffic Control and Autonavigators", in Interavia No. 11, 1958, p. 1208, etc.



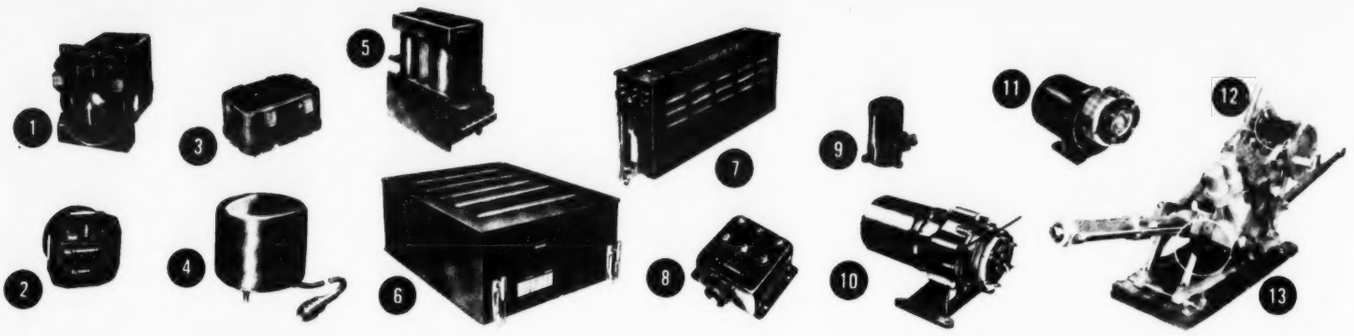
Electronic profile of a scheduled jet flight

A	B	C	D	E	F	G	H
Taxi and take-off	Climb	Cruise (short stages)	Climb cruise (longer stages)	Holding	Descent and landing approach	Landing	Taxi to parking area

Communications Equipment (1—7), Radio Navigation Equipment (8—20) and Semi-Electronic Aids for Piloting (21—26)

No.	Designation and Number fitted	Boeing 707	Douglas DC-8	Convair CV-880	D. H. Comet 4	Sud-Aviation Caravelle	Leading manufacturers
		O	T	T	O	T	
1	VHF Communications Systems	2	2 (3)	2	2	2	ARC, Bendix, Bronzavia, Collins, Lear, Marconi, Murphy, Narco, SARAM, Standard etc.
2	HF Communications Systems	2	2	1 (2)	2	1	Aerocom, Bendix, Collins, Marconi, Murphy, Standard, etc.
3	MF/HF Communications Receivers	–	–	–	1	–	Marconi, etc.
4	UHF Communications Systems	–	–	–	–	–	Bendix, Collins, Lear, Marconi, SARAM, Standard, etc.
5	UHF Data Link	–	–	–	–	–	Collins, IT & T, LMT, RCA, etc.
6	Interphone System	1	1	1	1	1	Bendix, Collins, Gables, Lear, Marconi, Standard, TEAM, Ultra, etc.
7	Passenger Address System	1	1	1	1	1	Air Equipement, ARC, Bendix, Collins, Gables, Lear, Murphy, RCA, Trix, etc.
8	VOR and Localizer Receivers	2	2	2	2	2	ARC, Bendix, Collins, Lear, Marconi, Narco, Standard, etc.
9	DMET Distance Measuring Systems	(2)	(2)	(2)	–	–	Bendix, Collins, IT & T, LMT, Standard, etc.
10	Automatic Direction Finder Systems	2	2	2	2	2	Air Equipement, ARC, Bendix, Collins, CSF, Lear, Marconi, Radio Air, SFIM, etc.
11	Marker Beacon Receivers	1	1	1	1	1	Bendix, Collins, Lear, Marconi, RCA, Standard, etc.
12	Decca Receiver and Flight Log	–	–	–	1	–	Decca Navigator Co. (Bendix, CSF)
13	Loran Receiving Set	1	1	(1)	1	–	Edo, Murphy, RCA, etc.
14	Dectra Receiver	–	–	–	1	–	Decca Navigator Co. (CSF)
15	Doppler Radar Navigation System	(1)	(1)	(1)	–	–	Bendix, Canadian Marconi, Collins, Decca Radar Co., GPL, Marconi, North American, etc.
16	Dead Reckoning Computers	(1)	(1)	(1)	–	–	Bendix, CARL, CDC, Collins, Crouzet, Ford Instr., GPL, Kelvin-Hughes, Librascope, Marconi, etc.
17	Rebecca Navigational Aid	–	–	–	1	–	Murphy
18	ATC Transponder Beacon	1	1	1 (2)	–	–	Collins, Cossor, RCA, etc.
19	UHF Glide Slope Receivers	2	2	2	2	2	Bendix, Collins, Lear, Marconi, Standard, etc.
20	SHF Airborne Search Radar	1	1	1	1	(1)	Bendix, Collins, CSF, Ekco, RCA, etc.
21	Remote Compass Systems	2 (3)	2 (3)	2	2	2	Bendix, Collins, Lear, Smiths, Sperry, etc.
22	Altitude Reference Systems	2	2	2	2	2	Bendix, Collins, Lear, Smiths, Sperry, etc.
23	Air Data System	1	1	1	1	1	Bendix, Kollsman, etc.
24	Automatic Pilot	1	1	1	1	2	Bendix, Collins, Elliott, Lear, Minneapolis-Honeywell, SFENA, Smiths, Sperry, etc.
25	Flight Director Systems	2	2	2	2	2	Bendix, Collins, Kelvin-Hughes, Lear, Smiths, Sperry, etc.
26	Flight Data Recorder	1	1	1	1	1	Bendix, IT & T, Minneapolis-Honeywell, Sperry, etc.

Numbers in brackets are optional • O = in operation • T = under test



Main components of the Bendix PB-20 automatic flight control system, a special version of which is fitted in e. g. the Boeing 707.

1 – **Controller** . . . permits adjustment of heading and pitch when flying on the autopilot.

2 – **Three-axis trim indicator** . . . for visual monitoring of surface servo load.

3 – **Three-axis rate control** . . . consists of three rate gyros for roll, pitch and yaw control.

4 – **Vertical gyro control** . . . senses displacements in pitch and roll, and generates control signals, which are combined with the rate gyro output for attitude stabilization.

5 – **Air data sensor** . . . senses static and dynamic air pressure data for altitude and airspeed control and computing of Mach number from true airspeed and air temperature: provides correcting signals.

6 – **Amplifier and computer** . . . contains plug-in racks for various circuits, e. g., amplifiers, electronic limiters, signal isolation transformers, etc.

7 – **Power junction box** . . . contains power transformer, capacitors, rectifiers, filter choke, etc.

8 – **Adapter** . . . contains potentiometers for adjustment of signal gain with aircraft flight characteristics.

9 – **Dynamic vertical sensor** . . . an oil-damped pendulum-type lateral accelerometer for detecting slip and skid; supplies corrective signals.

10 – **Surface servo** . . . an electric motor and reduction gear assembly, which operates control surface in response to autopilot signals.

11 – **Trim servo** . . . positions horizontal stabilizer (or tab) whenever elevator is under load. A similar type is used as thrust servo.

12 – **Position transmitter** . . . measures angular position of control surface and supplies feedback signal to the autopilot computer.

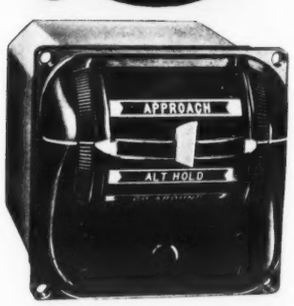
13 – **Hydraulic load sensor** . . . used in systems with hydraulic boost to sense surface load.

Indicators and Flight Reference Selector for the Sperry Integrated Instrument System (IIS)

Gyrosyn Compass Indicator (C-6): Main instrument for one of the two remote compass systems, shows heading (here 45 degrees magnetic), selected course (here 80 degrees magnetic), which is set by means of the left-hand knob, and finally the bearings from the ADF or VOR system (slender pointer No. 1 and broad pointer No. 2). A warning signal (top right) shows a plus sign or a circle if the remote directional gyro reading does not tally with the magnetic heading (from the fluxgate): bottom right, the synchronizing knob for manual correction.

Horizon Flight Director Indicator (HZ-1): In principle an artificial horizon combined with a Zero Reader, this instrument tells the pilot whether he is making the correct control movements to place the aircraft on the desired three-dimensional flight path or keep it there. The vertical pointer supplies control information to reach the desired course, the horizontal pointer that for the glide path or required altitude. If both pointers are in central position, the pilot or autopilot is doing the right thing. The regulator knob moves the miniature aircraft upwards or downwards to mark the desired climb or glide attitude.

Pictorial Deviation Indicator (R-1): Shows the aircraft's position relative to the required course, regardless of whether the latter is a VOR radial or an ILS localizer beam (V-shaped pointer, with rotary and lateral motion). The horizontal pointer shows the deviation from the ILS glide slope, and the instrument also contains a VOR radial selector with window showing course selected. This instrument replaces the conventional ILS cross-pointer instrument.



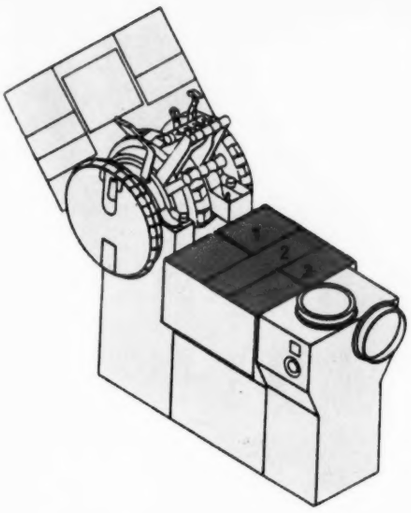
Flight Reference Selector: This control instrument selects the desired mode of operation for the Sperry Flight Director, e. g., approach (by the ILS method). It contains a radio switch which can be set at "blue left" or "blue right" for localizer reception, depending on whether the aircraft is flying to or from the beacon ("off" position in centre). Other modes of operation are "altitude hold", "go-around" and "flight instruments".

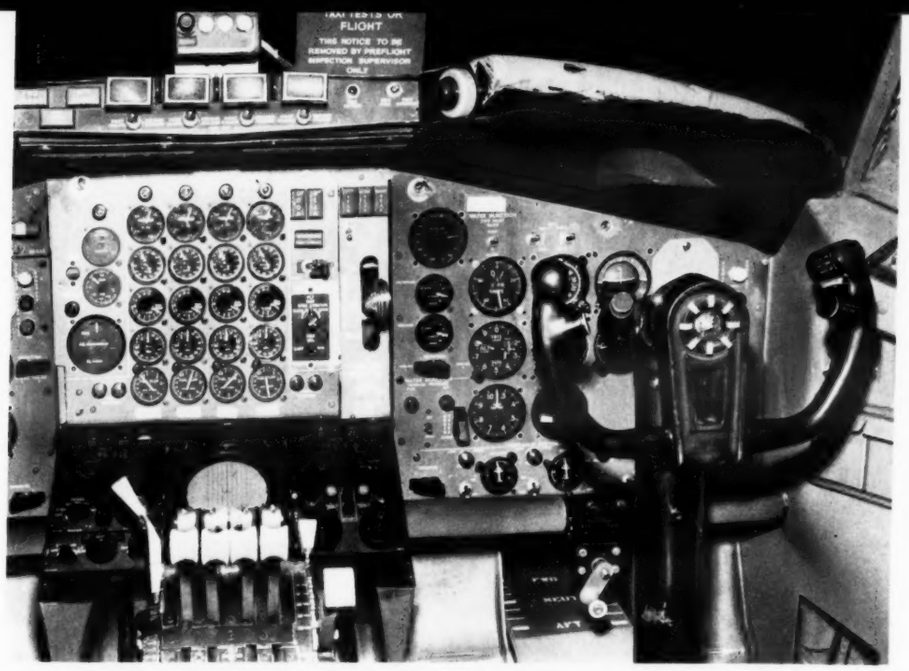
the Flight Log used in conjunction with the Decca/Dectra system, which can be combined with the DIAN Doppler navigation installation. Whereas autonavigators of group 2 (Doppler radar plus dead reckoner) are projected for installation in the American long-range jets (Boeing 707, Douglas DC-8, Convair CV 880) for most airlines, British Overseas Airways Corporation plans to equip its North Atlantic *Comet 4s* with Flight Logs for Decca-Dectra.

*

For communications purposes, i.e., for immediate request for and receipt of airport weather information, landing permission and

The new Kollsman combined airspeed and angle-of-attack indicator . . . is fitted in many jet airliners. As the white segment on the edge of the scale (calibrated in degrees) turns under the influence of the angle-of-attack sensor in the KIFIS (Kollsman Integrated Flight Instrument System), the slender pointer shows both the airspeed (in knots) and the angle of attack. The segment contains a green mark (recommended angle of attack for landing approach) and a red mark (stall angle of attack): the striped pointer indicates the maximum permissible airspeed for the prevailing flight conditions.





The most important control instruments for the Boeing 707's radio equipment are placed before and behind the central engine control pedestal and are thus accessible to both pilots. Picture and drawing show only one typical installation.

The forward panel contains the control units for the two ADF systems and the HF communications transmitter-receiver with Selcal adjunct, also the control unit for the airborne radar, the latter's screen (centre) and a control unit for the ATC transponder (bottom left).

The rear panel (shaded in the drawing) contains: 1. two station boxes for all transmitter and receiver systems, interphones and passenger address system; 2. control unit for the Bendix PB-20 flight control system; 3. two operating switches each for VHF communications and VOR/Localizer navigation. The emergency cut-out knob for the flight control system is mounted on the right-hand branch of each control column.

other traffic control information in air-to-ground-to-air operation, jet aircraft can make use of the following airborne radio equipment:

d) Advanced VHF and HF equipment, in multiple installations and with increasing numbers of channels, plus selective calling (Selcal) equipment.

Communications channels in areas of high traffic density, however, are notoriously overloaded. It must therefore be expected that additional communications systems will have to supplement the conventional methods in the fairly near future. These include:

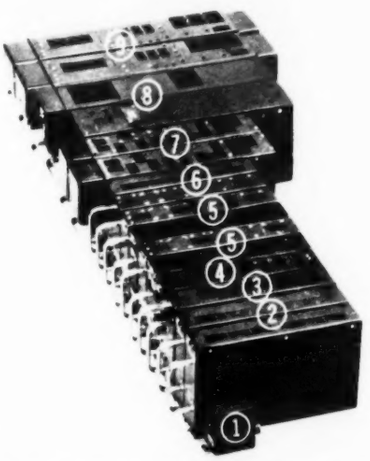
e) automatic message transmission and reply systems, of the TACAN Data Link category (cf. *Interavia* No. 6, 1957, p. 553, etc.).

f) UHF communications equipment, as already in general use in military traffic control operations.

g) radio teleprinters.

Finally, many commercial jet aircraft will carry *ATC transponders* which, on interrogation, will automatically transmit the aircraft's identification (and eventually its altitude) to the control authorities, and practically all will be equipped with *airborne radar.* The latter provides the pilot with direct en route weather information and facilitates navigation in coastal regions by "map painting" on the cockpit radar screen.

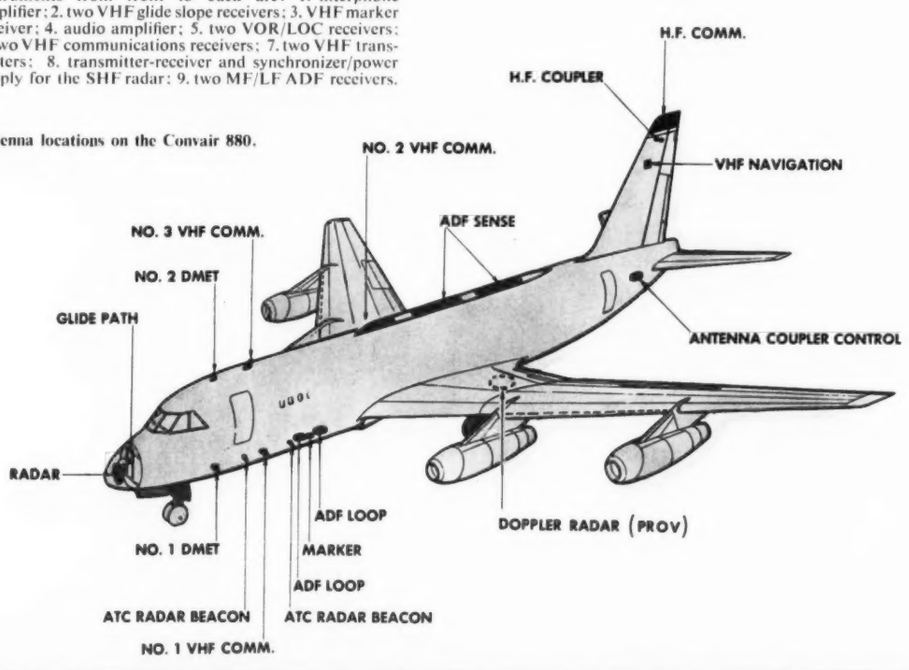
In addition to these aids, the overworked pilot demands an increasing degree of **automation** to facilitate his task, at any rate in all routine matters. The oldest equipment designed to this end is the *autopilot,* which has been in use in air transport for decades and is today available in many different types and sub-types. No modern airliner can be imagined without an autopilot, certainly not the jets. Why?



Array of "black boxes" for the radio equipment in a commercial transport, from the Bendix "Advanced Design" weight and space saving series. Individual instruments from front to back are: 1. interphone amplifier; 2. two VHF glide slope receivers; 3. VHF marker receiver; 4. audio amplifier; 5. two VOR/LOC receivers; 6. two VHF communications receivers; 7. two VHF transmitters; 8. transmitter-receiver and synchronizer/power supply for the SHF radar; 9. two MF/LF ADF receivers.

The automatic pilot frees the human pilot from the necessity of constantly "flying" the aircraft . . . watching horizon and landmarks, or compass course and altimeter, or cross-pointer instrument, or turn-and-bank indicator and artificial horizon. Every pilot well knows how much attention this monotonous work requires and how fatiguing it can be even on a short flight, particularly in aircraft which have a more than normal tendency to roll or yaw. When an autopilot is used, the human pilot has his hands (and feet) and—even more

Antenna locations on the Convair 880.



Scanner unit of the Ekco E160 SHF radar in the fuselage nose of a de Havilland *Comet 4* for Aerolineas Argentinas. The equipment is used for storm warning and as auxiliary for navigation over coastal areas and river courses.

important—his eyes and ears free for other tasks. A slight twist of the "turn" knob on the control unit . . . the controls move as if guided by ghostly hands, and the aircraft goes into a clean-cut left or right turn. The magnetic course on the compass indicator is reset, or the VOR course on the course selector, and the aircraft turns docilely into the decreed new direction. Last but not least, the autopilot is vital for keeping the aircraft on a straight "bee-line" course, thus achieving maximum economic operation.

In recent years these autopilots have been expanded, through combination with *flight directors*, to form integrated control and instrument systems. Such well-known instrument manufacturers as Bendix, Collins, Lear, Smiths and Sperry all have integrated systems of this kind. Whereas the task of the autopilot is to "fly" the aircraft automatically, the flight director is designed to enable the pilot to check at all times whether the aircraft is being *correctly* flown. One example of such an installation is the Sperry Integrated Instrument System (IIS) illustrated here, and another is the Collins Integrated Flight System (IFS) discussed in a later article. Brief descriptions of how these systems work are given in the appropriate picture captions.

Further valuable aid in piloting is provided by the *angle of attack indicator* which has recently been added to certain airspeed indicators (e.g., the Kollsman instrument for the DC-8). The optimum approach speed—to take only this example—depends very decisively on the aircraft's weight and is also affected by the angle of bank when flying turns, whereas the optimum angle of attack—even in a turn—remains constant. Thus if the pilot can read off both the angle of attack and the indicated airspeed at a single glance, he is immediately relieved of a great deal of unnecessary calculation or estimation.

In addition, plans are already being made for a still greater degree of automation in future airliners, through the installation of "*go/no go*" *computers* for particularly critical flight phases such as take-off, economical cruise and landing. As the ability to take off safely not only depends on the aircraft's weight and the available runway length, but is also affected by ambient temperature and pressure and by the acceleration characteristics of the engines, the "go/no go" computer would be vastly superior to the judgment of any human pilot, however well trained. The plan is to equip the indicator for this computer with two pointers—one to show the desired situation, the other the actual situation—so that the pilot can immediately see whether his aircraft is behaving normally or not.

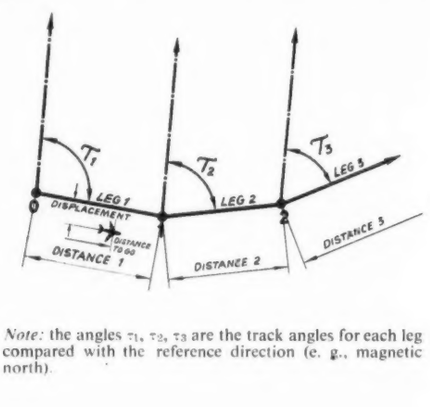
Finally it should be mentioned that all jet airliners carry extensive **attitude reference and air data systems,** which also use electronic equipment. The former are designed to show the correct position of the horizon in both manual and automatic flight (by means of one or more gyros), while the latter give a very accurate indication (with elimination of scale error) of the barometric altitude and indicated airspeed. They also compute true airspeed (dependent on air density) and Mach number (dependent on TAS and ambient temperature).

Main indicator for the General Precision Laboratory Radan 500 Doppler navigation system, for drift angle (top) and ground speed (figure drum).

*

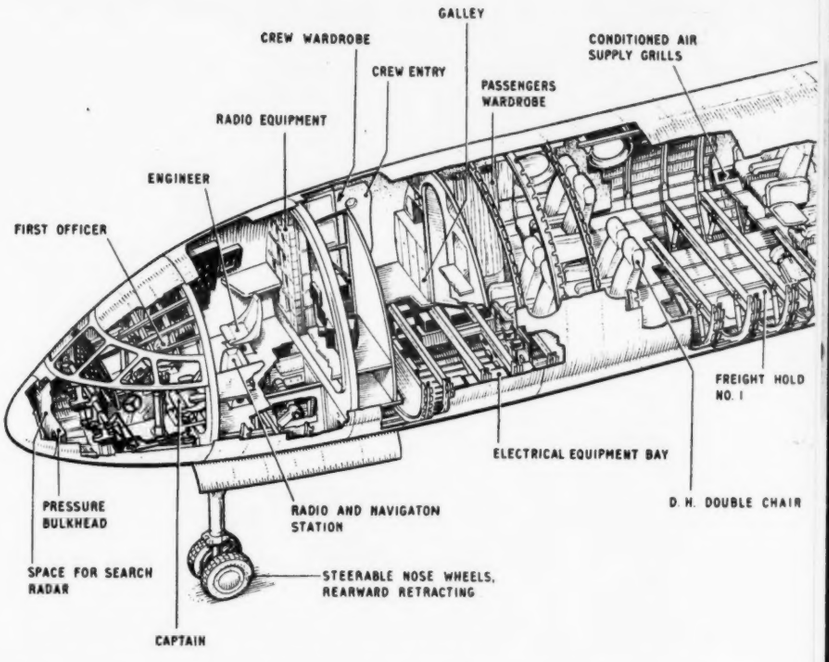
All the electronic systems for jet airliners briefly referred to here are listed in the *table* at the beginning of this article. The latter is also accompanied by the "*electronic profile*" of a scheduled jet flight showing the flight phases in which the various equipment is required. It should specifically be noted that the table contains only the electronic equipment used for actual piloting and navigation and omits the many other electronic devices for engine control, measuring fuel supplies and consumption, for the air-conditioning system, etc.

All Doppler navigation systems can be combined with automatic dead reckoning computers. Below is the control indicator (GPL's TNC-50) for such a computer. If, as is usual over the North Atlantic, the crew follows a minimum time track, this will be broken down into a number of straight legs of precisely determined direction (track angle in degrees of arc) and length (distance in nautical miles; see drawing). Track angle and distance for Leg 1 and Leg 2 are set in the four upper windows by turning the appropriate knobs, whereupon the system is set into operation when flying over reference point 0. The computer then shows the distance to go on the first leg by turning back the figures in the centre left window, and presents any left or right deviations from the desired track as "displacement" in the bottom window for Leg 1. Once distance zero is reached, the computer automatically switches the indicator over to Leg 2, whereupon the data for the next (third) leg can be set up. Corrections to the distance to go and displacement values can be made at any time, on the basis of accurate position finding by radio or celestial bearings; the output signals for the system can be fed into the autopilot and flight director system.



Note: the angles τ_1, τ_2, τ_3 are the track angles for each leg compared with the reference direction (e. g., magnetic north).

The Comet 4's Radio Installation

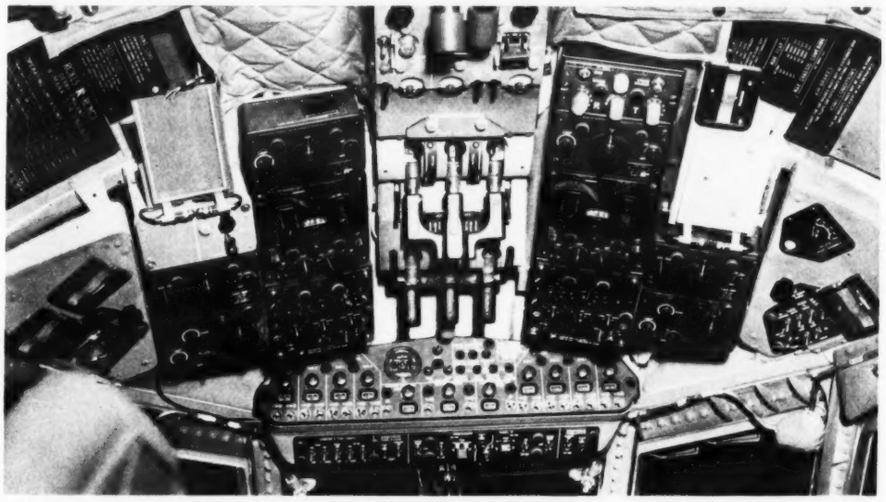


Layout of the four "stations" on the flight deck: the navigator sits on the left, behind the captain; the flight engineer's seat is behind the first officer's.

During the past seven years the *Comet* has undergone a step-by-step development programme culminating in today's world-wide *Comet 4* operations. In parallel with this the aircraft's radio equipment has steadily been improved to give outstanding performance and reliability.

The main feature of the equipment developed for the *Comet 4* is that it has been designed for operation from either pilot's seat. With regard to the HF communications equipment, provision has also been made so that it can be operated by the navigator. Similarly the controls and display of the automatic direction finder are available for the navigator. In planning the actual layout of the radio equipment, particular attention has been given to ease of operation; the instruments, for example, have been positioned most carefully to avoid parallax. The fact that the *Comet's* instrument panel is simpler than is usually found on piston-engined and turboprop aircraft has simplified the task and avoided the necessity for compromise.

The majority of the radio units are located on six shelves in SBAC racking on the starboard side of the flight deck; the back of this is panelled in to form the galley wall. Several hundred watts are dissipated in this small space and forced cooling is applied.



The *Comet's* radio equipment can be operated with equal ease from either right-hand or left-hand pilot's seat. Above the captain's head (from top to bottom) are: frequency for selector VHF navigation; one of the control units for the two ADF equipments; frequency selectors for VHF and HF voice communications; station box for intercom. The first officer's controls are arranged in similar order, but also include the control unit for the *Rebecca Mk.8B* VHF distance measuring equipment.

Main instrument panel with Decca Flight Log. The six main instruments (in front of each pilot's seat) are installed in duplicate and outlined in white. Left to right: top row, airspeed indicator, director horizon for the Smiths Flight System and rate-of-climb indicator; bottom row, altimeter, beam compass for the Smiths system and radio magnetic indicator for VOR navigation. Right, next to the captain's six main instruments, are the Machmeter, radio magnetic indicator for the ADF, cathode ray tube for the airborne radar.

Marconi AD 307 communications equipment

The ability to transfer an aircraft quickly from one route to another to carry out a flight to an entirely different part of the world is a commercial operating necessity. For this reason the equipment has been designed to avoid the time wasted in retuning radio.

The HF equipment is a fully automatic self-tuning receiver incorporating 200 channels; these cover the band from 2 to 24 megacycles· 50 frequencies are available between 2 and 3.7 megacycles, 80 between 3.7 and 6.92 megacycles, 50 between 6.92 and 12.9 megacycles and 20 between 12.9 and 24 megacycles.

The equipment has given extremely satisfactory results on the daily trans-Atlantic *Comet* opera-

tions. On many occasions the *Comet* has been in contact with both sides of the Atlantic—obviously a considerable operational advantage with high-speed jet aircraft.

Marconi Selcal decoder and AD 118 MF/HF receiver

The Selcal system is designed to avoid the necessity of maintaining a continuous listening watch. The unit contains musical reeds which, on receiving the tone allocated to the aircraft, operate audio and visual warning signals.

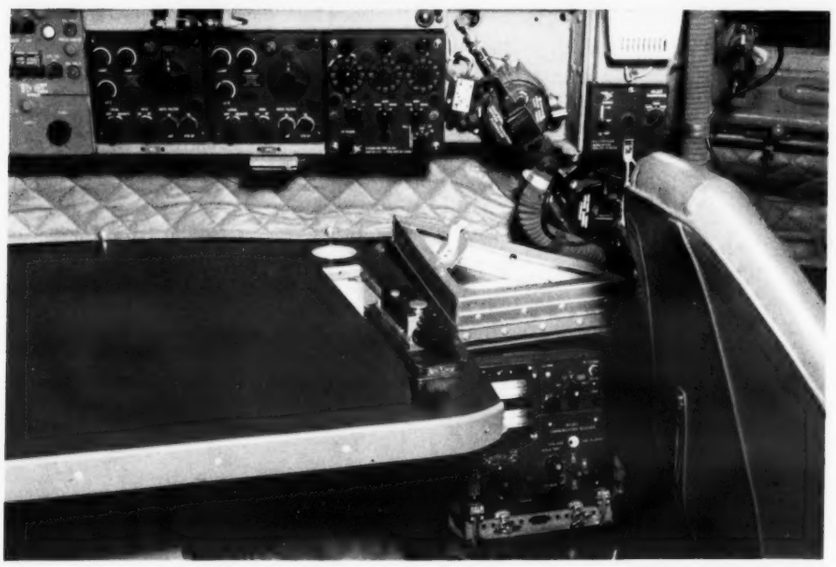
The AD 118 receiver, a direct development of the AD 94, can be used as a stand-by HF receiver or for certain weather or broadcast stations for which crystals would not be available in the main HF equipment. It can also be used to receive Consol or radio range signals should both ADF receivers be required for other purposes.

Marconi AD 305/704 VHF equipment and AD 706 glide slope receiver

The VHF equipment employs a separate transmitter and receiver to cover from 118 to 136 megacycles (output—30 watts); this is to allow the same receiver to be used for the VOR and ILS localizer. This means that the *Comet 4*, with its ILS/VOR system separate from the VHF communications system, has in fact four AD 704 receivers available on the aircraft, both systems being duplicated. The ILS/VOR controllers can be used to select communications frequencies so that, in the unlikely event of a VHF receiver failing, an ILS/VOR receiver can be substituted without physically changing the equipment.

The AD 706 is the ILS glide slope receiver associated with the AD 704; it has a double superhet covering a range of frequencies from 329.3 to 335 megacycles. All glide slope frequencies are paired with a given localizer frequency; for example, the glide slope frequency 332.3 megacycles is paired with the localizer frequency of 111.3 megacycles. It is thus only necessary to select the localizer frequency in order to obtain both frequencies.

The output signals of each of the two ILS equipments are fed into the Smiths flight system to be displayed on two cross-pointer indicators (one for each pilot), while a single cross-pointer instrument displays the unselected equipment on the captain's panel. Successful approaches have been made down to 250 ft. above ground level with the ILS signals fed into the auto-pilot. A similar system makes it possible to apply VOR signals to the beam compass of the Smiths flight system; in this instance a separate omni-bearing selector in the pilot's panel indicates a pre-set track or "radial" for the pilot to fly. This too can be coupled to the auto-pilot. VOR signals can also be indicated independently on two radio magnetic indicators, one of which is fitted to each side of the instrument panel.



Front end of navigators table with control units for the two Marconi AD 307 HF transmitter-receivers, a morse key (for the former) and the intercom station box. Below the table (the corner of which can be raised) is the Marconi AD 118 MF/HF receiver, which can be used as stand-by equipment or for certain weather or broadcast station messages, Consol or radio range signals, etc.

To the left of the navigator's table the following equipment is installed: drift meter (far left) and Loran receiver (with rectangular cathode ray tube), two sets of indicators and control units for the Marconi AD 712 ADF, indicators for ambient air temperature, Mach number, bearing angle for the RMI of the ADF equipment, and for altitude . . . and another intercom station box.

Marconi AD 708 receiver

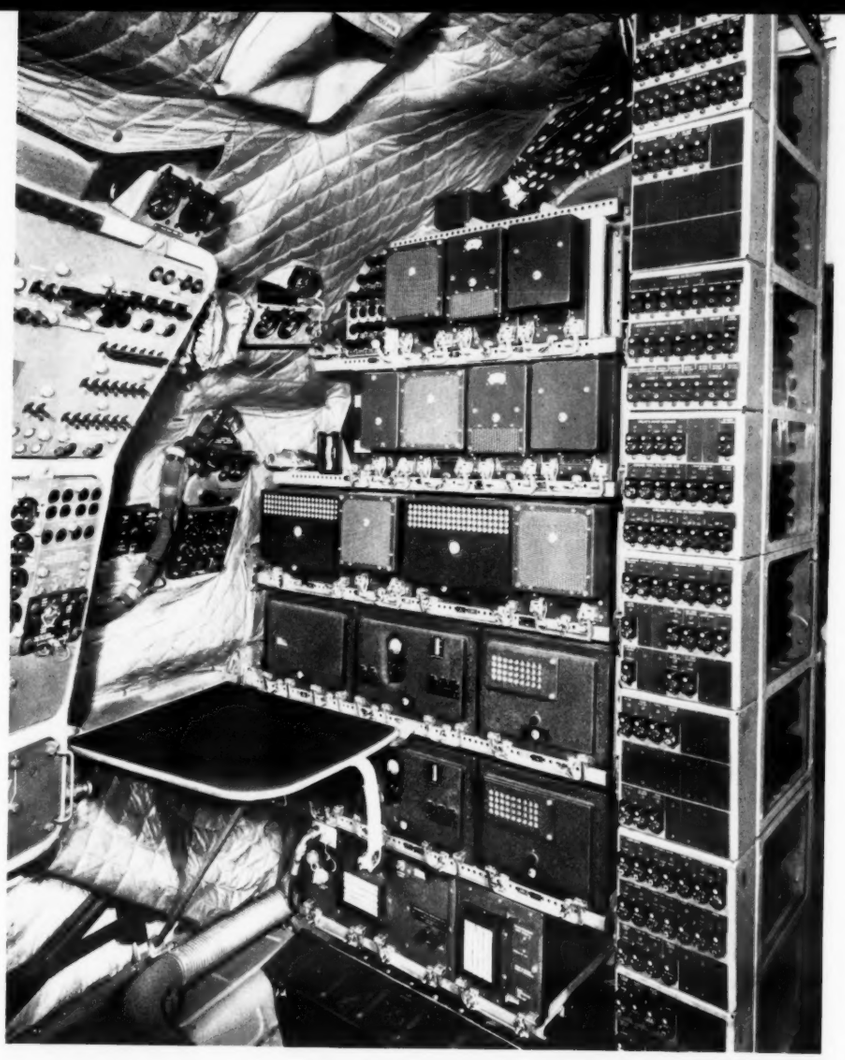
The marker receiver gives an overhead indication as soon as the aircraft passes over the outer, middle or inner marker beacons on the ILS approach. These all operate on the same frequency (75 megacycles), each having a distinguishing modulating tone. Filters decide which signal is being received and these operate a circuit which lights the indicator lamps in the pilot's panels.

Marconi AD 712 automatic direction finder

The two most important features of the automatic direction finding equipment are the fixed-loop Bellini-Tosi system and the crystal-locked self-tuning system. Two-speed gear boxes drive the tuning mechanism by means of electromagnetic clutches. To tune a station it is merely necessary to select the appropriate frequency on the control, leaving the actual tuning of the receiver to be carried out by the appropriate combination of crystal oscillators. As the smallest step is 0.5 kilocycles, all beacons can be received without the aid of a fine tuning system, the band width of the transmitter being normally greater than 0.5 kilocycles.

Ultra UA 56 intercom

The intercommunication and mixing system is transistorized and requires only a 28 volt supply. An unusual feature is the application of the "ring main" principle to all crew station boxes. Further



Behind the engineer's station is an impressive array of Marconi radio equipment. The two top rows each contain an AD 704 VHF navigation receiver with Type 2642 bearing computer and Type AD 706 glide slope receiver, plus (far left) the Selcal supplement; third row, dual Type AD 305/AD 704 VHF multi-channel transmitter and receiver; below, the two AD 307 HF transmitter-receivers with modulator and power amplifier.

intercommunication points are available in the fore and aft galleys, and at the nose-wheel and the hydraulic and electrical equipment bays.

Murphy Mk.8B Rebecca distance measuring equipment and Loran receiver

The main purpose of the DME is to enable the pilot to carry out his descent from cruising height so as to arrive overhead at the destination at an appropriate altitude for joining. For this reason a range of 200 miles at 40,000 feet is required. The system employs a transmitter in the aircraft; this interrogates the ground beacon, thus obtaining the necessary return signal. A meter, which shows the distance of the aircraft from the ground beacon in nautical miles and also provides a left/right indication, is fitted to the pilot's instrument panel.

Loran, is a long-range hyperbolic tracking system presented on a cathode-ray tube at the navigator's position on the flight deck.

Trix TR 520 passenger address system

Announcements can be made to the passengers in the main cabins by the captain from the flight deck or the cabin staff from the forward galley. The equipment can also be used for the relay of music.

Ekco Type El 60 airborne search radar

For storm-warning (detection of cumulo-nimbus cloud formations) and navigational aid purposes (map painting of shore lines, islands and other topographical features) use is made of an Ekco El60 airborne search radar (power output 60 kW) working in the 3.2-cm range (X-band). Fitted with a pitch and roll stabilized mirror of 18 in. or 24 in. diameter, the equipment has a maximum of 120 nautical miles and an azimuth coverage of ± 80 degrees.

Decca/Dectra LF airborne equipment with Flight Log

As a result of comprehensive trials over the North Atlantic by a Ministry of Supply *Comet 2E*, BOAC has decided to equip its entire Atlantic *Comet 4* fleet with Decca/Dectra equipment, including Flight Log. The highly accurate Decca short distance navigation system (for distances of up to 300 nautical miles) will enable these aircraft to use the new westward climb-out path (Amber One Decca = A1D) to be introduced in the London Terminal Control Area on an experimental basis this summer. The Dectra equipment will enable precise position information to be obtained at all times over the North Atlantic (Dectra stations at Prestwick and Gander).

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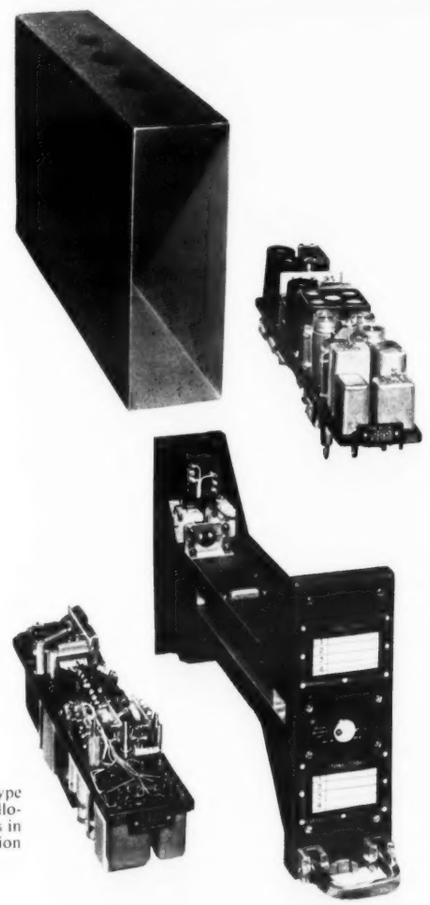
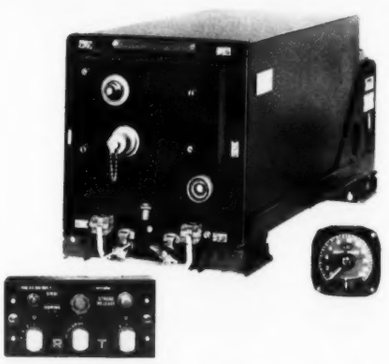
Jet operations pose a number of special radio problems, among them the need for increased range and simpler operation. The radio installation has shown itself to be matched to the *Comet's* performance and reliability in service.



The Selective Calling adjunct to the HF receiver (Marconi, Type 2880) contains musical reeds which, on receiving the tone allocated to the aircraft, operate audio and visual warning signals in the flight deck. This informs the pilots that the ground station desires to communicate with them on a given channel.

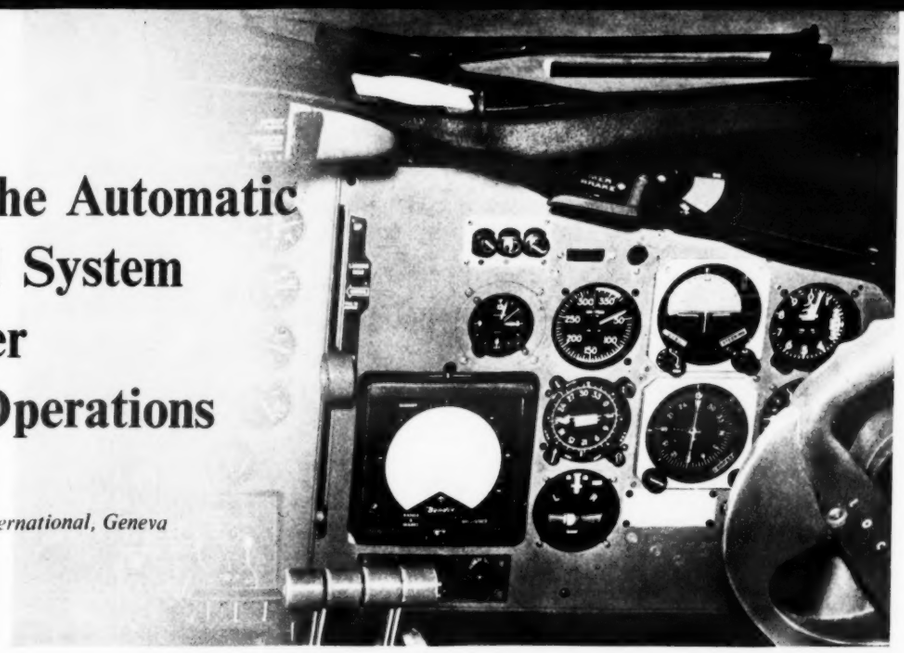


Main components of the Murphy *Rebecca Mk. 8B* VHF distance measuring equipment: above, the TR 332 transmitter-receiver; below, control unit and meter unit with circular scale (for distance) and left/right pointer (for heading).

One of the five Ultra UA 561 station boxes for intercom aboard the *Comet 4*. All radio communications and navigation signals can be heard by each member of the crew.

The Role of the Automatic Flight Control System in All-Weather Jet Aircraft Operations

By R. V. Bruland, Collins Radio International, Geneva



The co-pilot's flight instruments in a Lockheed *Electra*: immediately in front of the control column are the Approach Horizon and Course Indicator for the Collins IFS system; to their left the three marker indicator lights, also clock, airspeed indicator, master compass (plus RMI), turn-and-bank indicator and screen for Bendix radar. Far right are the altimeter and rate-of-climb indicator.

With the introduction of new types of high performance turbojet and prop-jet aircraft, the designers of electronic flight control systems have been given a new set of performance requirements which are more severe in all respects than for the slower piston-engine types. Higher speed imposes the requirement for faster response to signals from sensing elements, and a higher degree of precision in translating these stimuli into command forces for control of the aircraft. In some cases it has been necessary to develop new types of transducers to more accurately measure position, velocity, or acceleration and convert it to the proper form to provide adequate stabilization of the electronic/kinematic control loops.

Since response of a jet aircraft to control surface movement varies considerably over the wide range of airspeeds and altitudes through which they operate, it may in some cases be necessary to use Mach-number or altitude transducers, or both, to automatically vary control sensitivity. Directional instability under certain flight conditions is not uncommon in jet aircraft. A "yaw damper" feature is now available as a part of the flight control system to counteract this effect.

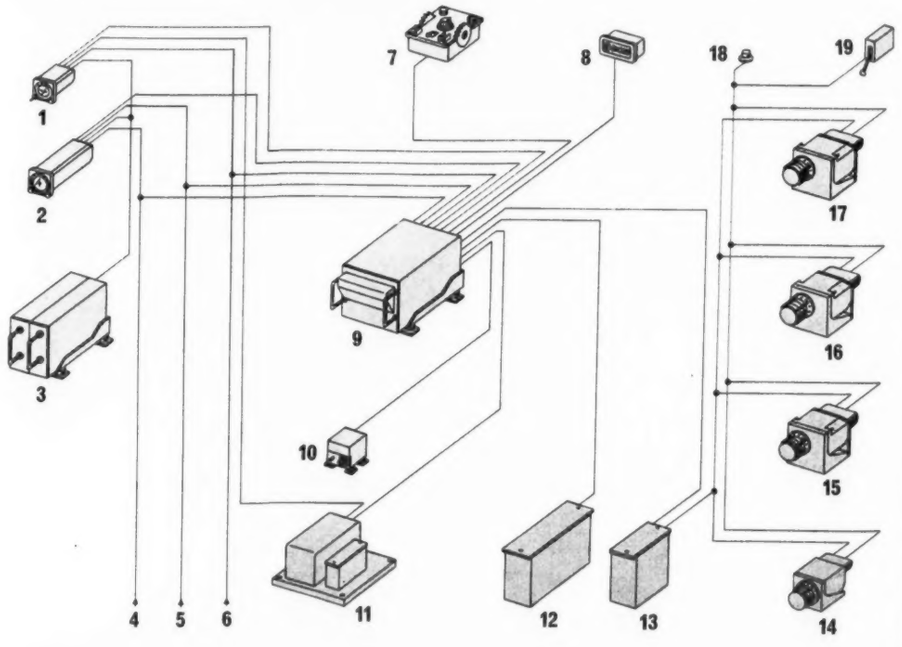
Terminal area navigation includes three principal phases:

1. Entry of aircraft into the terminal area and alignment with the approach path.
2. Progress along the approach path to approximately 200 feet altitude above the terrain.
3. From 200 feet to visual breakout and landing.

Under IFR conditions, only phase 2 is presently being satisfactorily accomplished on a routine operational basis. Rapidly increasing air traffic in the vicinity of the larger air terminals has created a demand for a higher frequency of runway utilization, which will require drastically lowered minimums, or ideally, truly all-weather approach and landing operations. The urgency of this problem is being further accentuated by the introduction of jet aircraft, adding the important economic and operational factor of very high fuel consumption rates at low altitudes.

Control unit for the Collins AP 103 autopilot: top right, the "engage" knob; top left, warning light to indicate when the autopilot is disengaged (the actual disengage switch is on the control column); in the centre is the selector for four modes (plus altitude switch) and the turn control knob; left and right a trim control.

Circuit for the Collins combined autopilot and Flight Director System (AP 103 with FD 105): 1. IFS Approach Horizon; 2. IFS Course Indicator; 3. amplifier and steering computer; 4. signals from remote compass; 5. signals from VOR/LOC receiver; 6. signals from glide slope receiver; 7. autopilot control unit; 8. trim indicator; 9. autopilot amplifier; 10. barometric altitude control; 11. vertical reference (gyro system); 12. inertial sensors; 13. calibration control; 14. trim tab servo; 15. elevator servo; 16. rudder servo; 17. aileron servo; 18. quick disconnect; 19. emergency disconnect.



The ultimate solution of the terminal area problem cannot yet be clearly foreseen. In recent years, however, considerable progress has been made in the development of automatic air traffic control systems, using modern data processing equipment. It is probable that the present time-consuming radio-telephone system for ground-air communications will eventually be replaced by high speed data transmission equipment, operated in conjunction with the automatic control system.

Automatic landing systems, which have been under development in both the United States and the United Kingdom for several years, show great promise as methods of increasing the frequency of approach and landing operations under adverse visibility conditions. By reducing the number of procedure turns during phase 1 (entry into the terminal area and alignment with the approach path), considerable savings of time and fuel can be effected. By providing accurate control of the aircraft during phase 3 (final approach from the middle marker down to and including touchdown), landing operations may be greatly accelerated during minimal ceiling and visibility conditions.

The use of guidance signals from a conventional ILS installation, with a properly designed approach coupler and automatic pilot system, make possible automatic approaches which are entirely acceptable. Under experimental conditions, such approaches have been made automatically all the way to touchdown, but due to inherent limitations of the ILS system, particularly during phase 3, ILS approaches in scheduled operations are now continued only as far as the prescribed minimum altitude (usually 200 feet), after which the pilot must either continue the landing manually by referring to visual aids, or execute an overshoot maneuver.

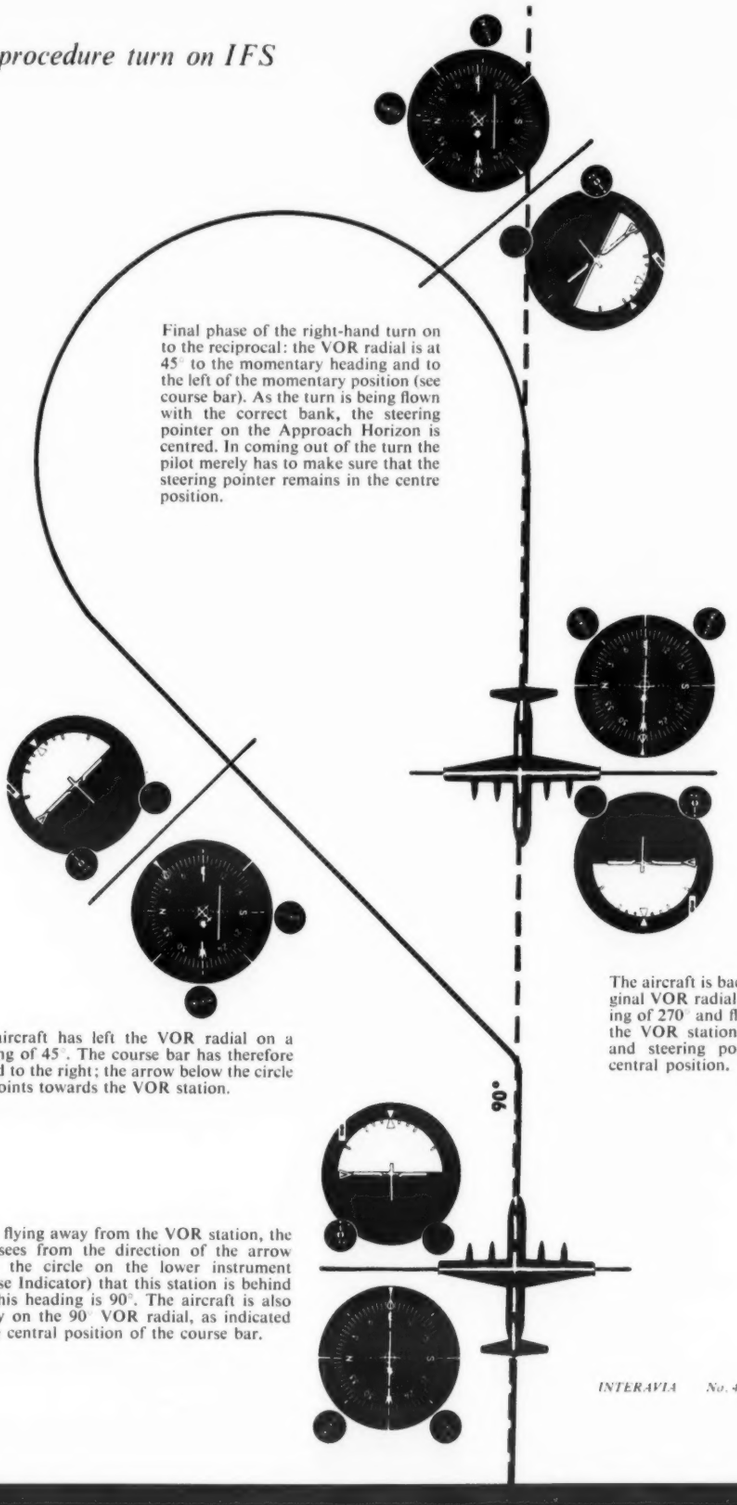
There are several schools of thought as to the most desirable manner of overcoming these limitations to provide fully automatic landings. In the British B.L.E.U. (Blind Landing Experimental Unit) system, the best combination of lateral and vertical guidance systems is used during each of several segments of the approach and landing path, with automatic switching of systems between segments to provide continuity of control. The Bell Aircraft Corporation's system uses a ground-based precision tracking radar, with data processing equipment, properly programmed to compute control commands, which are transmitted to the aircraft on ILS frequencies. Although these and other automatic landing systems differ in their method of deriving information regarding the aircraft's deviation from the proper approach and landing path, they all use a flight control system aboard the aircraft as a means of processing deviation and attitude information and developing and applying properly coordinated forces to the aircraft's control surfaces.

The modern electronic flight control system, then, is capable of providing both en route and terminal area control, using existing facilities and procedures. It can also be adapted for operation with more advanced techniques, such as atomatic landings, when the technical means become generally available. Addition of auxiliary circuitry may be necessary in some cases, such as an automatic flareout control, set into operation by a selected response from a radar altimeter or distance measuring equipment, or perhaps by a signal from a marker beacon. Although the experimental automatic landing systems referred to above have been in operation for some time, and several thousand landings have been successfully accomplished with them, a great deal more research is required before they will be used for routine IFR landings.

One of the principal factors in determining the acceptability of an automatic landing system for scheduled airline use will be an accurate appraisal of its reliability, which must be based on a statistical analysis of failure rates of both ground and airborne equipments. A high degree of equipment reliability, together with instrumentation which will permit the pilot to adequately monitor system performance throughout the approach and landing will be essential in developing pilot confidence in the system.

It is not sufficient for the pilot to be able to monitor only the outer loop of the control system, which contains only position informa-

A procedure turn on IFS



Final phase of the right-hand turn on to the reciprocal: the VOR radial is at 45° to the momentary heading and to the left of the momentary position (see course bar). As the turn is being flown with the correct bank, the steering pointer on the Approach Horizon is centred. In coming out of the turn the pilot merely has to make sure that the steering pointer remains in the centre position.

The aircraft has left the VOR radial on a heading of 45°. The course bar has therefore moved to the right; the arrow below the circle still points towards the VOR station.

The aircraft is back on the original VOR radial with a heading of 270° and flying towards the VOR station: course bar and steering pointer are in central position.

When flying away from the VOR station, the pilot sees from the direction of the arrow below the circle on the lower instrument (Course Indicator) that this station is behind him; his heading is 90°. The aircraft is also exactly on the 90° VOR radial, as indicated by the central position of the course bar.

A Boeing 707 makes an automatic landing by the Bell Aircraft Corporation system: the ground equipment seen on the right of the picture includes: 1. radar equipment for measuring distance, height, speed and course of the approaching aircraft: 2. a computer, which continuously compares these data with the standards for optimum landing approach: 3. a radio transmitter to pass corrective signals to the automatic control system aboard the aircraft.

tion. He must also be able to verify correct performance of other factors which contribute to normal system operation. Typical of modern electronic flight control design is the Collins AP-103 system, which includes the FD-105 Flight Director as an integral part of the system. Since the same computer circuits provide control signals for both instrument and flight control functions, the instruments give an accurate indication of control system performance. Aircraft position, attitude, and heading information, as well as steering command information, are shown in a logical pictorial presentation on two instruments:

The Course Indicator provides a "plan view" of the situation, combining aircraft heading, desired heading, heading error, radio deviation, selected course, and ambiguity (in the case of VOR navigation). These factors are combined in the Collins Course Indicator to make a "plan view" presentation, showing the aircraft position and heading with relation to the desired heading and VOR or localizer course. The Course Indicator also includes knobs for setting in desired heading and selected VOR course, plus a flag which monitors normal functioning of the heading reference system.

The Approach Horizon combines pitch and roll information with a glide slope deviation indicator and a steering pointer which displays computed steering command information. Under IFR conditions, this "forward view" instrument provides the attitude and vertical position information which a pilot normally obtains under VFR conditions by visual reference to the horizon, the runway, etc. The psychological advantages of this presentation, particularly during ILS approaches, are obvious. The Approach Horizon also contains flags which warn of malfunction of the glide slope, localizer, vertical attitude reference, and steering computer functions.

A third indicator displays trim conditions of the three major control surfaces.

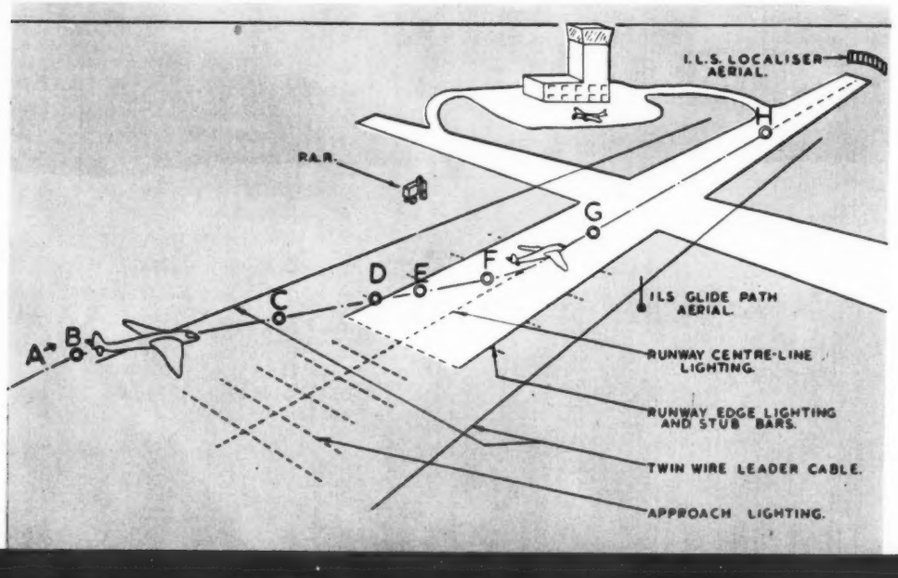
This combination of instruments provides the pilot with an accurate and complete integrated picture of his aircraft's position, attitude, and heading, as well as a continuous visual check on the operational status of the major components comprising the system.

Reliability of airborne equipment has been the subject of intensive investigations in recent years. In designing the AP-103 Automatic Flight Control System, Collins engineers eliminated all vacuum tubes, which have always been responsible for the majority of airborne equipment failures. In their place, highly efficient transistors and rugged magnetic amplifiers have been combined to produce virtually trouble-free computer and amplifier units. New types of Glide Slope and VOR/LOC receivers utilize the latest design techniques to achieve high standards of efficiency and reliability by means of circuit simplification. As a natural consequence of these improvements, the new equipments are also much smaller and lighter in weight than their predecessors.

In those instances where, due to the necessarily delicate nature of certain components, a higher than normal incidence of failure is expected, redundant circuits or units may be provided. As an example, dual flight director systems have been specified in many jet aircraft, in order to provide both pilots with complete, independent navigation instruments. Because of its highly flexible design, either flight director may be connected through selector switches to the Automatic Flight Control System at will. In the steering computer, modular magnetic servo amplifiers may be paralleled if desired. In the event of failure of any single component of one amplifier, the other will continue to function normally. Only selected, highest quality components are used, and all airborne equipments are mechanically designed to withstand rigorous testing over broad ranges of temperature, humidity, and vibration. Production quality is continuously policed by a special group of quality control experts.

Operational use of fully automatic landing systems is an inevitable consequence of the rapid parallel advances of aeronautical technology and airways utilization, and its ultimate realization will be merely a matter of properly applying presently known techniques. One of the principal remaining hurdles is a psychological one, and investigations are now in progress to help overcome it by further improving monitoring techniques and equipment reliability. It is expected that these improvements in both airborne and ground portions of the automatic landing systems, plus the use of auxiliary monitoring means, such as conventional ILS, GCA, and precision terminal area radar in conjunction with airborne ATC transponders will all contribute to the accomplishment of the ultimate goal—truly all-weather flying.

Diagram of the blind landing procedure designed by the Royal Aircraft Establishment's Blind Landing Experimental Unit: with autopilot switched on the aircraft flies at constant altitude from *A* to *B*, following the signals from the localizer receiver and the barometric altitude control. At *B* it is "picked up" by the glide slope beam and guided to point *C*. Here the signals from the two magnetic leader cables take the place of the localizer signals, but the aircraft remains on the glide slope until *D*. Beyond *D* the glide slope receiver is disconnected, and the aircraft now approaches the runway at a fixed (optimum) attitude. At *E* a highly sensitive radio altimeter goes into action, gradually increasing the aircraft's angle of attack and thus flattening out the flight path. At *F* any drift angle present (difference between magnetic heading and course) is eliminated, whereupon the aircraft touches down at *G* and taxies out under manual control (to point *H*).



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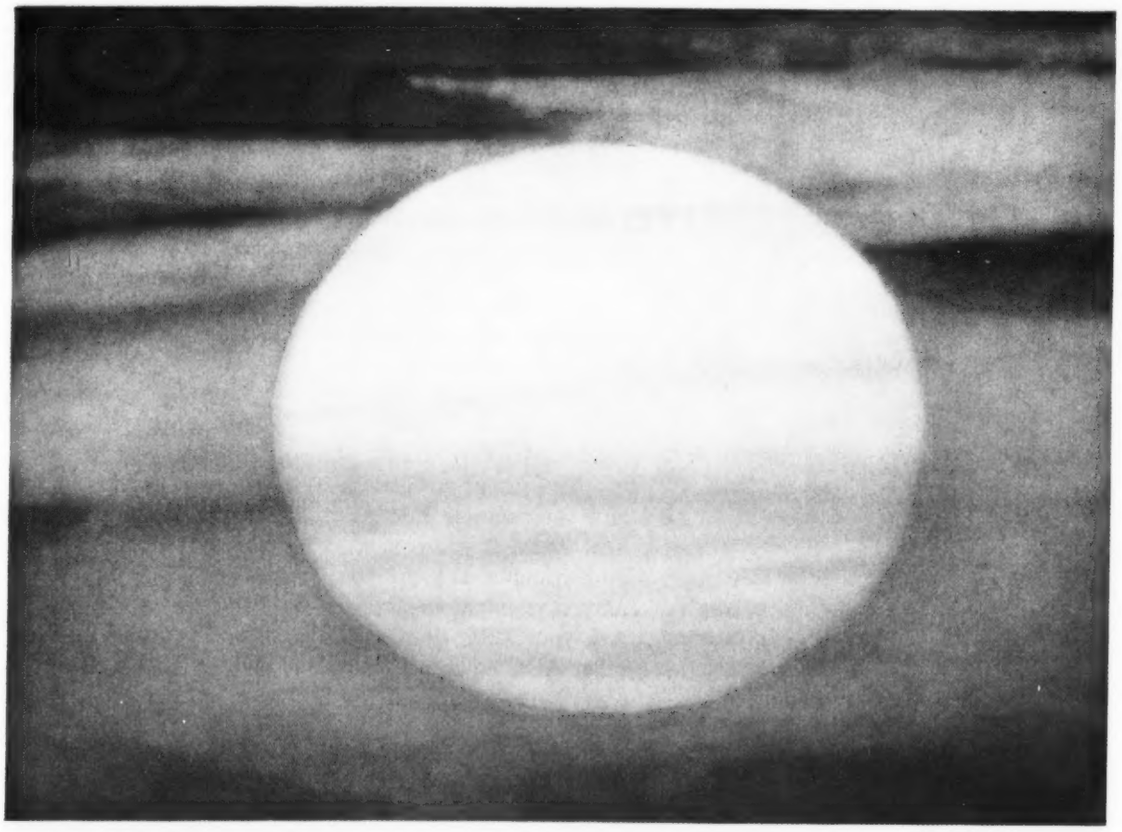

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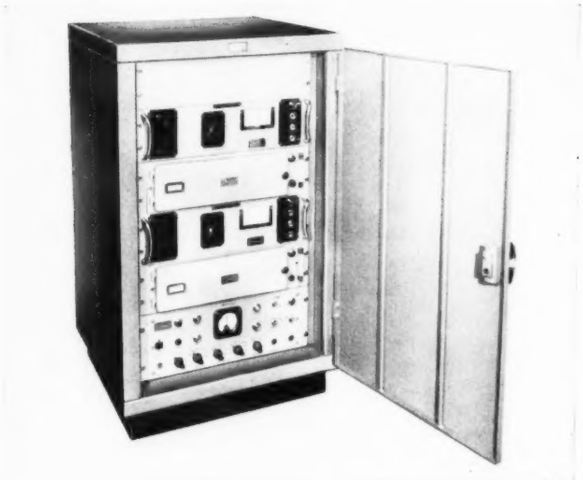

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A Weapons System without Weapons

Global weather reconnaissance by USAF jet transports

The exploration of the troposphere and the stratosphere, and the determination of major weather developments on a global basis have always been the concern of aviation. But meteorology is of vital importance not only to military and civil flying, but also to the whole national economy, which can draw great profit from a fast-working, world-wide weather observation system. Hurricanes, floods, droughts or cold spells cause millions of dollars worth of damage every year in many countries, not to mention the losses which certain branches of the economy (agriculture, building, etc.) suffer through unreliable or tardy weather forecasts.

It is therefore not surprising that the demand for improved "meteorological reconnaissance" should have arisen in the United States, with its very varied climatic conditions. Artificial earth satellites equipped with television cameras and other optical recording instruments to observe weather developments from a great height are a substantial step forward. *Interavia* drew attention to this possibility more than two years ago[1], and the successful launching of the *Vanguard* weather satellite in February 1959 has confirmed the earlier prediction.

Earth satellites orbiting at altitudes of hundreds or thousands of miles can make optical observations, or at best radiation measurements, only above the cloud layer. They cannot detect the details of what takes place in the lower layers of the atmosphere. This gap is now to be closed by a different system, which was first revealed to the public at the recent Bendix engineering conferences in Frankfurt and Paris[2].

Under contract to the Wright Air Development Center, Bendix has developed a complex, airborne *weather observation system, the AN/AMQ-15, for installation in the USAF's jet transports.* Boeing is providing the airframe for testing the AN/AMQ-15 and is later to supply a larger number of KC-135s to take the production weather reconnaissance system. Flying weather stations of this kind will enable the U.S. Air Weather Service to receive constant meteorological and geophysical data from throughout the world and instantly pass them on to military and civil aviation services, the National Weather Bureau and various research centres.

*

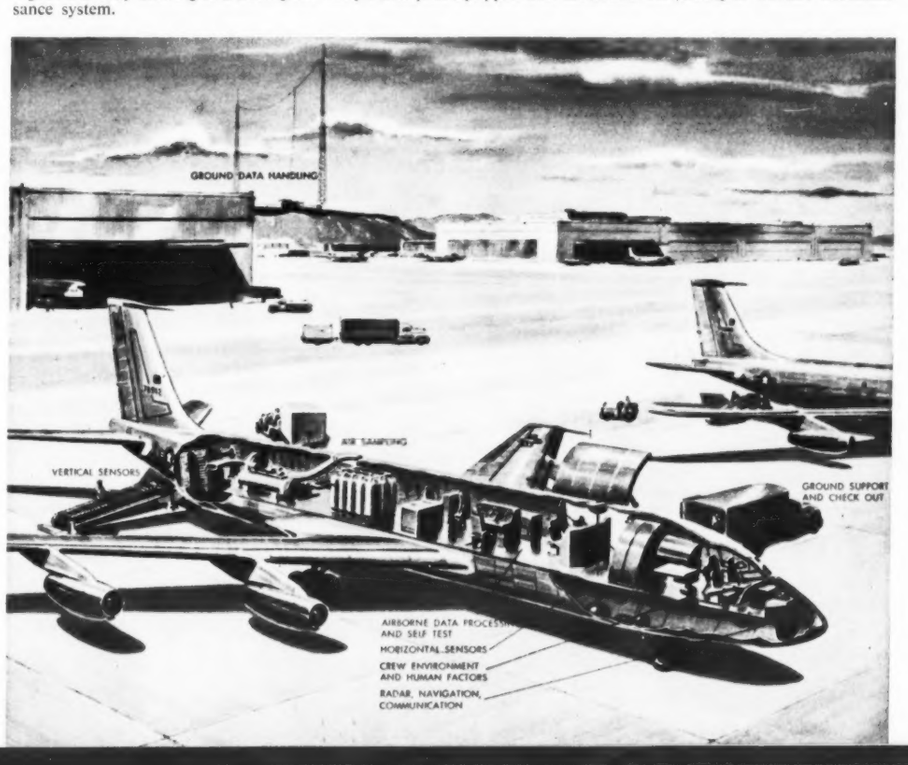
Bendix Systems Division is to receive more than $30,000,000 under a three-year development contract for the AN/AMQ-15, a project to which the Air Force attaches the greatest importance, for obvious reasons. Long-range bombers, aircraft carrier units, airborne units and tactical missile groups can all operate with reduced risk and... lower cost, if the weather conditions throughout their operational zone are accurately known. Needless to say, such a development would also benefit the air transport industry. At the moment, however, this is a purely military project, which – in view of its extensiveness and its urgency – is being treated as a weapons system, although the KC-135s equipped with AN/AMQ-15 will harm no-one. At any rate the four-jet mother aircraft with its complete weather reconnaissance system bears the USAF designation WS-460L. The contract has been awarded by the Aerial Reconnaissance Laboratory, Wright Air Development Center, and bears the number AF 33(600)-37984. So much for a description of the new project. But how do Bendix and the Air Force envisage the flying weather laboratory in detail?

From the beginning both have clearly realized that the planned airborne system must be capable of doing more than measure pressure, air temperature, humidity and wind force, as is done today. Instead a total of thirteen different meteorological and geophysical parameters are to be measured along the whole flight path, namely:

1. pressure
2. temperature
3. atmospheric electricity
4. dew point
5. icing rate
6. atmospheric content
7. albedo
8. turbulence
9. ozone
10. D-value
11. visibility
12. wind
13. index of refraction

Eight of these values (pressure, temperature, dew point, wind, albedo, turbulence, ozone and index of refraction) will also be measured intermittently over a wide altitude range –

Fig. 1: Cutaway drawing of a Boeing KC-135 jet transport equipped with the Bendix AN/AMQ-15 weather reconnaissance system.



[1] "The Artificial Earth Satellite – Past, Present, and Future", by S.F. Singer, in *Interavia* No. 12, 1956, p. 956, etc.

[2] Cf. *Interavia* No. 3, 1959, pp. 295 – 296.

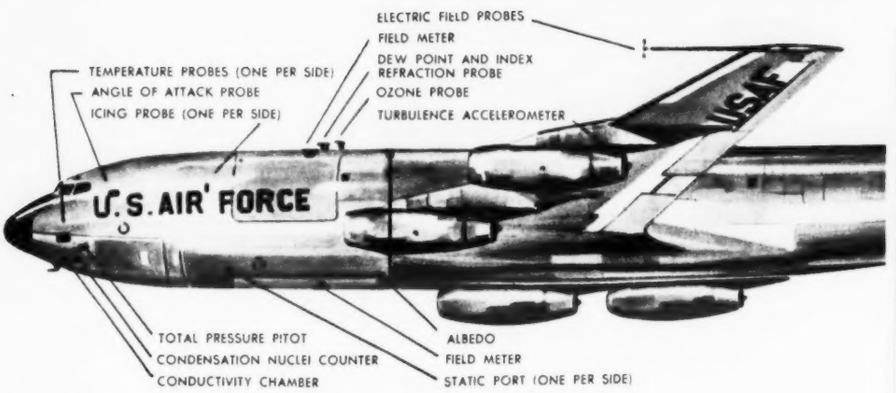


Fig. 2: The arrangement of the principal measuring equipment.

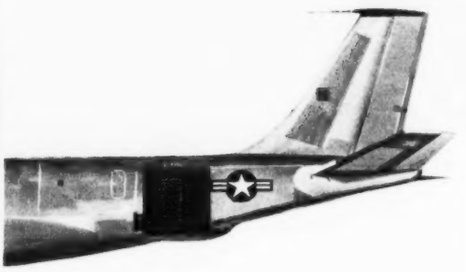


Fig. 3: Towards the rear of the fuselage is the dispenser for the rocketsondes, followed by a similar dispenser for the dropsondes.

from ground level up to 150,000 feet – with the aid of rocketsondes and dropsondes. In addition a vertical scanning radar will detect and automatically record the upper and lower limits of cloud layers. A horizontal scanning radar will detect storm formations up to 150 miles from the aircraft; its information will be handled by a semi-automatic processing system, which will provide size, shape, intensity and movement of the storm front.

This complex equipment will be carried aloft for periods of 12 hours by aircraft flying at speeds of up to Mach 0.95 and altitudes of 55,000 feet. A single mission of this kind can cover a range of 4,800 nautical miles. Hence a relatively small number of such high-speed, far-ranging jet transports could cover the whole globe within a short space of time. So that the information collected during a flight can be passed to the Air Weather Service in a useful form and as quickly as possible, the many data will be processed, coordinated, stored and recorded on magnetic tape aboard the aircraft. Synoptic and operational data will be transmitted in digital form over secure radio communications to USAF ground stations during flight. Research data and air samples of general interest will be stored for retrieval and analysis after landing. No wonder that an aircraft the size of the 100-ton-plus Boeing KC-135 is required to carry complicated and extensive equipment over intercontinental distances.

*

The aircraft to carry the complete AN/AMQ-15 system is shown in *Figs 1 and 2*. The whole fuselage will be packed full of equipment of all kinds, and the skin will bristle with probes, ducts and other measuring instruments. Inside the nose of the aircraft, behind a dielectric cover, will be a C-band radar whose horizontal scan will cover a sector of 240° and follow storms within 150 miles for periods of 15 to 20 minutes. A camera PPI will provide a permanent record of storm clouds. An observer seated in front of a second radar scope will constantly follow the size, shape and movement of such clouds. By means of a joystick he can position an electronically generated ellipse over any storm area and adjust it to match the storm. The data thus obtained, together with the observer's assessment of intensity, are then inserted into the airborne data processing system.

Behind the cockpit are the dual antennas for the K-band radar, one looking upwards and the other downwards, to measure the top and base of cloud up to an altitude of 100,000 feet. Its signals are recorded on a film, processed during flight, which will show cloud strata to an accuracy of ± 500 feet. The video signals from the two antennas will be converted into digital form and inserted into the data processing system to compute percentage of cloud cover.

On the sides and below the fuselage nose will be probes for temperature and pressure measurement, for measuring ice formation, air conductivity and condensation nuclei. A systematic measuring of conductivity and the concentration of condensation nuclei in the atmosphere could yield important information on the relationship between atmospheric electricity and weather conditions. The forward position of the fuselage also carries equipment to measure dew point (automatic mirror hygrometer), the index of refraction (X-band refractometer), the electric field (radio-active probe), ozone content (iodine dosiometer) and albedo (rotating mirror photometers scanning upwards and downwards). Visibility will be determined by utilizing a light path of some 100 feet from the front to the rear of the aircraft. Air scoops on top of the fuselage will collect samples, which will then be compressed and stored for subsequent analysis. Part of this air will be analyzed during flight by a mass spectrometer.

To enable measurements to be made at a still greater altitude, it is planned to use two dozen rocketsondes, which will be dropped from a dispenser *(Fig. 3)* at the rear of the fuselage at intervals of some 200 miles and launched vertically by means of a parachute-stabilized system. Each rocketsonde will be approximately 6 feet long, 6 inches in diameter, and weigh 120 lb. It will consist of a launch tube stabilized by three parachutes,

Fig. 4: The data processing and test equipment aboard the aircraft. At right, in front of the angled console, is the Weather Observer; centre, the Weather Technician, and left the Air Sampling Operator.

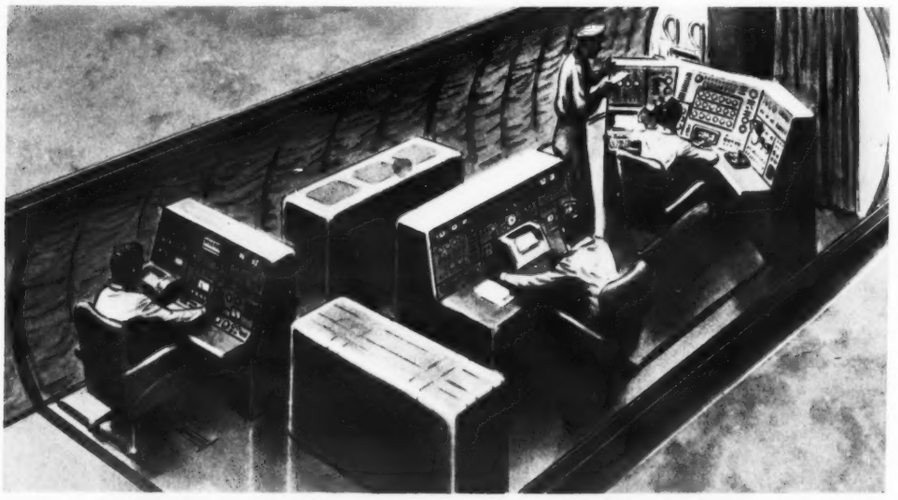


Fig. 5: Foreground, the Boeing KC-135 which is to be used as carrier aircraft for the AN/AMQ-15 equipment; behind, the Boeing 707 prototype which will flight test the first experimental installations.

the actual carrier rocket inside this tube, and the instrument package inside the rocket nose cone *(Fig. 6)*, which will be recovered by further parachutes. When the rocket has climbed to 150,000 feet, a protective nose cone over the instrument package is discarded, whereupon the instruments begin to descend on the parachutes at an initial speed of 200 ft./sec. Measurements below the aircraft are made by means of dropsondes released from another dispenser. These, like the rocketsondes, are released by a timer programmed by the weather observer.

A vital and weighty part of the AN/AMQ-15 is the airborne data processing subsystem—an electronic laboratory consisting of several units (Fig. 4), the heart of which is a multipurpose digital computer. The latter receives all sensor data, including those transmitted by the rocketsondes and dropsondes, corrects them and processes them, together with reference data from the aircraft. All data thus "digested" can be stored on magnetic tape. Raw data are also recorded to prevent loss of information in the event of malfunctioning of the computer. Synoptic information for in-flight transmission can be held, if necessary, until communication conditions are satisfactory.

The weather reconnaissance crew, working in the pressurized cabin, consists of three members: the Weather Observer already mentioned, who is responsible for the whole operation; a Weather Technician, who carries out pre-flight and in-flight tests of the equipment and prepares messages for transmission to the ground; and finally the Air Sampling Operator, who will control and monitor the sampling subsystem.

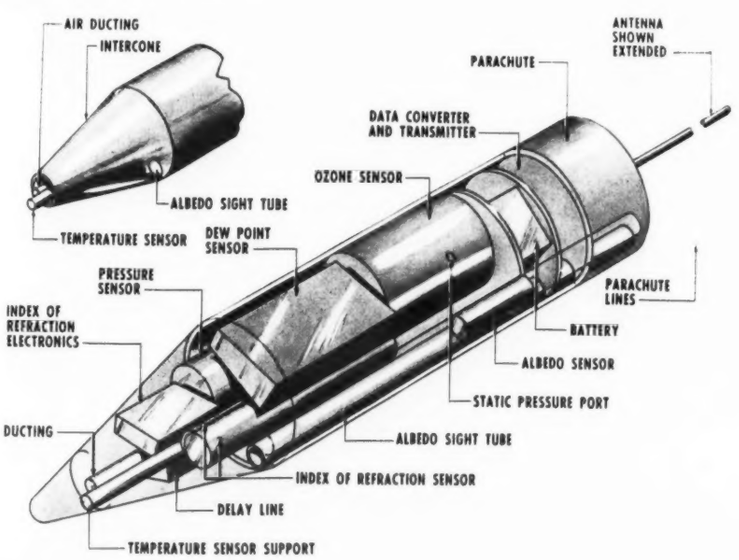
*

So much for details of the airborne equipment. One important point, however, should not be overlooked. Though the AN/AMQ-15 system has been designed in conjunction with Boeing's Transport Division (as suppliers of the aircraft), it has from the outset been laid out so as to be compatible with other carrier aircraft. It may be that some day even scheduled passenger or cargo aircraft may carry parts of a similar weather reconnaissance system, thus greatly extending the network of flying weather stations.

For the moment, however, this is a purely military project, as is also revealed by the fact that the AN/AMQ-15 can be used in conjunction with the USAF's WS 433-L data processing system and WS 456-L global communications network. And military thoroughness has been applied in planning the development programme for years ahead. Phase I of this programme will establish the feasibility of the selected techniques and finalize the design choice for prototype development. For this purpose test flights will be made in the Boeing 707 prototype. Phase II will then see the construction of equipment prototypes. Assuming that the flight tests in the Boeing 707 prototype reveal that the choice of the KC-135 is the right one for the carrier aircraft, four production models can be equipped with the first complete prototype elements of the AN/AMQ-15 and be ready for flight testing by the 30th month after the beginning of the programme. Meanwhile the rocketsondes will be tested at military firing ranges, and training programmes and logistic planning will be carried out concurrently with final prototype development and manufacture. By the 33rd month after the beginning of Phase I, prototype testing would be completed and final decisions taken on the future of the AN/AMQ-15.

The present report has given a glimpse of the *genesis* of a modern "weapons system without weapons", and it is hoped that a later article will be able to describe the *testing* of these flying weather stations.

Fig. 6: Instrument package for a rocketsonde.



The Alpha Approach[1]

By C. E. "Chuck" Myers, Jr., Engineering Test Pilot, Convair, A Division of General Dynamics Corporation, San Diego, Calif.

"Chuck" Myers is an Engineering Test Pilot for Convair, Vice President of the Society of Experimental Test Pilots, and Project Director of his own consulting business, Aerocounsel. He received a B.S. in Mechanical Engineering from Lafayette College in 1949. He graduated from Army Air Corps flight training in 1944 and from Navy flight training in 1951. During World War II and the Korean War he accumulated over a hundred combat missions as an Army and Navy pilot, respectively.

In 1954 C. E. Myers graduated from the Navy School of Test Pilot Training. After two years as a Navy test pilot he resigned to become project pilot on the XFY-1 "pogo stick". Since September 1956, "Chuck" has served as a test pilot for the F-102A and F-106A all-weather interceptors. *Ed.*

When landing a 15-ton high-performance fighter on a 7,000-foot runway under all-weather conditions, the pilot must consistently touch down within the first 1,000 feet of the runway. This means that he must fly the final approach along the proper glide slope at the optimum airspeed.

Summaries of aircraft accidents for the past five years indicate that flying the final approach is a more difficult task than it might appear. Over 30 percent of all accidents in the U.S. Air Force and the U.S. Navy have occurred during some phase of landing. These accidents fall into one or more of the following categories:

1. *Undershoot* (collision with the ground).
2. *Hard landing* (either late attempt to flare, or not enough speed to flare, or fast at flare: balloon and subsequent stall from 5 to 10 feet above runway).
3. *Stall during the approach* (steep turn either because of close downwind or overshooting crosswind, or incorrect airspeed/gross weight relationship).
4. *High sink rate* (traffic pattern was so tight that there was insufficient time for a reasonable glide slope. Pilot forced to perform power-off tight turn to final).
5. *Overshoot* (ran off far end of runway because the aircraft was too high or too fast over the fence).

Nearly all of these accidents are classed "100% Pilot Error". Is this then an indication that our fourth generation pilots are unequal to the task of flying the present breed of fighter aircraft? Perhaps this is the case. However, before passing judgment let us review the problem which faces the modern fighter pilot.

Variation in aircraft gross weight

The landing gross weight of today's fighter aircraft may vary as much as 10,000 pounds through the expenditure of fuel and/or weapons during the course of a mission. The optimum wings-level approach speed varies about two knots per thousand pounds. The recommended landing approach speed is based on a typical landing gross weight. Pilots will not generally fly at less than the recommended approach speed when below the typical weight; however, they will usually add an excessive amount for safety when approaching in a heavy condition. Landing with an extra ten knots increases the kinetic energy which must be dissipated by about seven percent. Whether or not this is of consequence depends on runway length and condition; at the very least it increases tire wear considerably.

More important, if the pilot uses his normal flare technique, touchdown will be delayed until the speed deteriorates to a normal value for touchdown. Ten knots of excess airspeed at the flare will amount to a loss of 1,500 feet of runway during the ensuing "float". This condition establishes a perfect environment for the "balloon" and stall type of accident. The net result of 10 knots of excess speed will vary from excessive tire wear to structural failure either from a hard landing or rolling over rough terrain after slithering off the end of a wet runway.

Bank angle

The added dynamic load, or increased g's, in a turn has the same effect as increasing the gross weight would have on the performance

[1] Alpha (α) is the symbol for angle of attack, i. e., the angle between the mean aerodynamic chord of an airfoil and the relative wind, or practically speaking, the angle between the longitudinal axis of the fuselage and the flight path.

Fig. 1: Power required and military power thrust available for a typical USAF fighter of the Century Series, plotted against airspeed (in knots) and gross weight (in pounds).

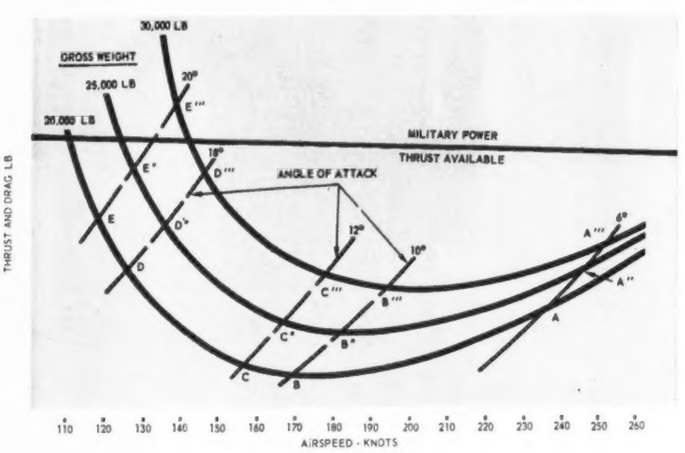
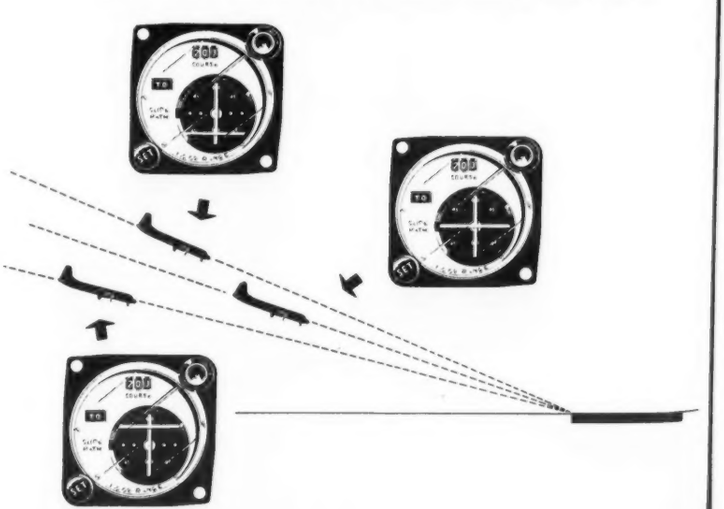


Fig. 2: Cockpit presentation for an Instrument Landing System approach.



of the aircraft. In order to maintain the optimum approach angle of attack when rolling into a turn, the airspeed must be increased by applying additional power or by increasing the angle of descent. The required increase in speed is related directly to the dynamic load which, in a balanced turn, is equal to 1 divided by the cosine of the angle of bank. The dynamic load increases slowly in shallow banks, reaches a value of 2 g's at 60 degrees, and builds up rapidly as the bank becomes still steeper *(see Table)*.

With most fighters, the optimum angle of attack can be maintained in turns by applying enough power to increase the airspeed about six-tenths of a knot for each degree of bank up to 40 degrees. In steeper turns it would be advisable to raise your speed by at least 1 knot per degree of bank. The power should be increased while rolling into the turn; when rolling out, power must be reduced to less than that required for optimum wings-level speed in order to dissipate the extra speed. Not knowing exactly how much the speed should be increased for the different bank angles, the pilot usually adds too much and comes out of the turn fast with no choice but to return to a reasonable wings-level speed. Such a transition usually results in a high sink rate which is difficult to overcome, especially when one considers the slow acceleration characteristics of a turbojet engine.

Stall speed

The stall of an airfoil occurs when the character of the airflow changes abruptly from streamline to turbulent; separation occurs, circulation and lift deteriorate, and pressure drag increases. The point at which an airfoil stalls is strictly a function of angle of attack. The term "stall speed" is meaningless until associated with a gross weight. The two may be combined to define a lift coefficient which in turn identifies the angle of attack.

The pilot, to be aware of how near the aircraft is to a stall, must have either a plot of stall airspeed versus gross weight, or a cockpit presentation of angle of attack. The plot, to be complete, would have to be stall speed versus gross weight per angle of bank, whereas the angle of attack at which stall occurs is the same regardless of the bank angle.

Power required and power available

A typical set of power required versus power available curves for a jet fighter is presented in *Figure 1*. Curve AE represents the power required at the minimum gross weight, while curve A″ E″ is a similar curve for the maximum gross weight. The dash lines represent constant angles of attack. The angle of attack at which this particular airplane stalls is 20 degrees. The optimum angle of attack for a landing approach has been determined to be 12 degrees. Examination of the curves reveals the following facts:

1. Less power is required to maintain level flight at B (170 knots) than at A (236 knots).

2. To maintain level flight at D (126 knots) requires more power than to fly at *either* points A or B.

3. The margin of power available for acceleration is represented by the vertical distance between any point and the power available curve. This margin decreases with an increase in gross weight and/or angle of attack.

4. The optimum approach speed varies with gross weight from 157 knots (light) to 177 knots (heavy). Points C, C″, and C‴ have only one thing in common; they are all oriented on a line of constant angle of attack.

Flying at angles of attack to the left of B B‴ has become commonly referred to as flying on "the back side of the curve". Most approaches are made slightly on "the back side of the curve", but no further to the left than is represented by C C‴. Such an approach permits the pilot to cross the fence at a minimum speed consistent with safety and yet allows plenty of margin for acceleration should it be necessary to take it around.

The stall area is difficult to define on some of the modern fighters; in any event, this area should never be approached since at typical landing weights there will be little or no power available for recovery from such a condition. For an airplane having characteristics as depicted in *Figure 1*, a stall warning device, if installed, should be set to react when the angle of attack reaches line D D‴ (18°). The pilot responds to the warning by applying military power which will bring him back toward C C‴ without sacrificing altitude. The pilot of the high-performance fighter should have a mental picture of the comparable family of curves for his particular model, or he must have at least memorized a half dozen weight/airspeed/thrust points in order to fly each approach at the optimum speed.

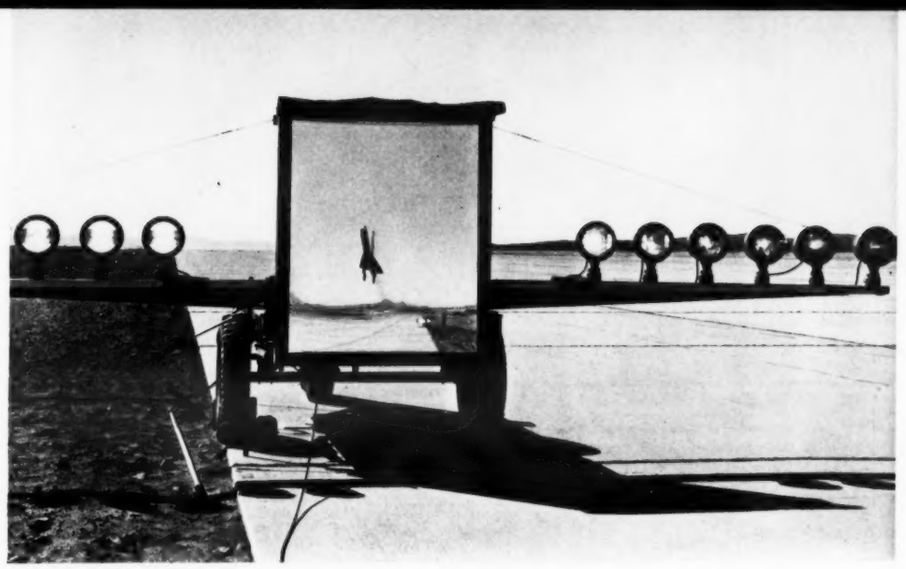


Fig. 3: The U. S. Navy's optical landing system, as used aboard today's aircraft carriers.

Load Factor, and Stalling Speed in Turns

Angle of bank	Load factor	Increase in stalling speed	Actual stall based on 100 knots
10°	1.02	0.5%	100.5
20°	1.06	3.0%	103.0
30°	1.15	7.0%	107.0
40°	1.30	14.4%	114.4
50°	1.56	25.0%	125.0
60°	2.00	41.4%	141.4
70°	2.92	71.0%	171.0
80°	5.75	140.0%	240.0

Approach flight-path angle[2]

There are basically two categories of approach:

1. Power approach with a glide slope of between two and four degrees. The rate of descent varies between 500 and 1,000 feet per minute.

2. Idle power approach with a glide slope of between seven and ten degrees and a rate of descent between 2,500 and 3,500 feet per minute.

The first type of approach should be flown at the optimum airspeed for the existing gross weight, a value which may be determined, when operating bomber or cargo-type aircraft, prior to beginning the approach by making reference to performance charts. This same power approach is currently being recommended for landing high-performance fighter aircraft.

The second approach, preceded by a hard break and tight pattern, is a "tactical leftover" from World War II. It is usually flown by fighter pilots to demonstrate their skill but under the guise of being a safe approach since the field could be made should the engine quit while in the traffic pattern—an extremely rare happening with jet aircraft. Such an approach is a necessary part of the flame out pattern for fighter aircraft. The approach must be flown at twenty to thirty knots above optimum speed to allow for the flare, a maneuver which must be started at least 100 feet above the runway.

Approach flight path aids

There are three readily available means of aiding the pilot in flying a three degree flight path angle; they are:

1. ILS (Instrument Landing System).
2. Optical Landing System.
3. PMOLA (Poor Man's Optical Landing Aid).

Item one, ILS, is the most commonly used means of establishing a correct glide slope during low visibility conditions (see *Figure 2*). When available, this system should be used for

[2] The angle between the horizontal reference and a line representing the aircraft's flight path.

Fig. 4: What the pilot sees in the PMOLA (Poor Man's Optical Landing Aid) system during a landing approach: in the left-hand picture he is too high, in the centre picture too low, and in the right-hand picture dead on.

landing under visual flight conditions. The Optical Landing System is standard equipment aboard aircraft carriers to aid in accomplishing the most critical of all landing approaches (see *Figure 3*). "PMOLA" has been used successfully both day and night; it is the least expensive and complex visual system available (see *Figure 4*). The "Mirror" and "PMOLA" are especially attractive since neither adds to the weight or complexity of the airframe. Utilization of such systems when available does not decrease the pilot's ability to perform a similar approach when the "aid" is unavailable; instead, it serves as a training device which develops a mental picture of a "proper approach".

Lift augmentation and approach speed

When performing a power approach at a 3-degree glide slope, a high-performance fighter may have an attitude (angle between the longitudinal axis of the fuselage and the horizontal reference) of between 8 and 10 degrees, nose up. Analysis of the forces involved during such an approach reveals that the vertical component of the thrust vector is contributing between 600 and 800 pounds to the total lift of the system. This contribution allows the pilot to fly the aircraft about three knots slower than would be possible if the aircraft were flying in a level attitude.

Another family of variables which the pilot must consider when determining the airspeed for a particular approach is the various devices employed to increase lift during low-speed flight: flaps, slats, boundary layer control, combinations of all three devices. The final approach speed may vary as much as 25 knots depending on the extent to which the above devices are used.

In determining the approach speed for a particular configuration, the flight test agency considers the following: 1. stability; 2. controllability; 3. stall characteristics; 4. power available versus power required; 5. forward visibility; 6. desire to land as slowly as possible; 7. sufficient speed to allow for flare. The published recommended approach speed is a practical figure for a typical gross weight. If the aircraft is to be landed at other than this weight the pilot must add or subtract accordingly if he is to perform the approach at the optimum speed.

Tools for the pilot

The equipment available to the pilot of the high-performance fighter for solving the landing-approach problem is the same old airspeed indicator his father used twenty years ago. The kid who is all wrapped up in a 30-degree bank on a five-degree glide slope with 70 percent fuel aboard and one-half flaps is expected to run through a mental calculation which will yield the optimum speed for this particular condition as well as tell him how far he is from a stall. The ungarbled word is that he is incapable of performing this task. If he had one additional piece of information available he could solve the problem in a second. The information to which I refer is angle of attack. Regardless of the angle of bank or gross weight, if the aircraft is at the correct angle of attack for the configuration, it will be at the optimum speed for the described flight condition.

Utilization of angle of attack instead of airspeed is not a revolutionary idea. The Wright brothers resorted to angle of attack to accomplish flight at the best lift over drag ratio (C_L/C_D) in order to overcome a power deficiency. In later years we became more interested in speed than lift efficiency, hence the airspeed indicator, a wonderful device for navigation but a meager aid for a precision landing approach.

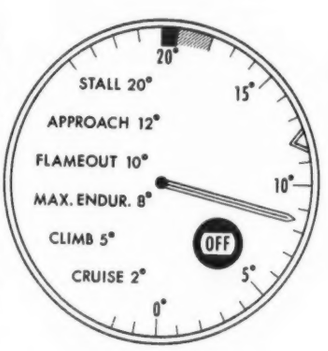


Fig. 5: Author's proposal for an angle-of-attack indicator on the standard instrument panel.

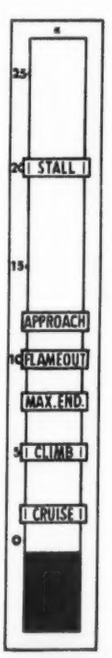


Fig. 6: Author's proposal for an angle-of-attack indicator on the USAF's future vertical panel.

Use of angle of attack during the approach

During the turn from downwind to base the pilot slows the aircraft by reducing power and maintaining altitude until the approach angle of attack is reached. During the descending turn from base to final, power is adjusted to maintain the approach angle of attack. In doing so, the airspeed which results will be the optimum airspeed for the current gross weight, bank angle, and normal acceleration. This same angle of attack will dictate the optimum airspeed during the final approach.

Experience has proven that the safest landing approach during visual flight conditions is the same as the approach which is flown under instrument conditions. This approach is characterised by a two and one-half to three-degree glide slope with sufficient power to maintain the correct approach airspeed. The common rule, "control airspeed with attitude and rate of descent with power", applies specifically to flying an instrument letdown, not a landing approach, as some have inferred.

A more practical approach technique is that prescribed by the U.S. Air Force Manual for Jet Instrument Flying; that is, make corrections to the flight path with elevator and change power to maintain the airspeed within limits of plus or minus five knots of target speed. This same technique is used to maintain the desired angle of attack, with the limits being plus or minus one-half degree.

The technique described will suffice to accomplish an approach at optimum airspeed during flight through smooth air and when the angle-of-attack system is operating properly. When flying through turbulent air the angle of attack will fluctuate considerably more than the airspeed indicator. During such periods the pilot should refrain from chasing the needle with power changes. The proper technique is to note the average of the needle movement and adjust power accordingly. *Never* attempt to chase angle of attack by changing aircraft *attitude*.

Pilots should not rely on the angle of attack presentation to the extent that they fail to recognize a system malfunction. Occasional crosschecks should be made of power, airspeed, and aircraft attitude; we can recognize a reasonable approach in terms of these items. The function of angle-of-attack information is to "optimize", not to serve as a guardian to be trusted and followed blindly.

Additional utility

An appealing aspect of a good angle-of-attack system is its utility. The same presentation which is used for landing will provide

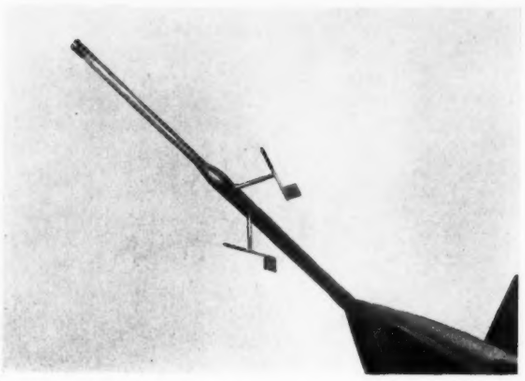


Fig. 7: Angle of attack and yaw detectors (mass-balanced vanes) on the standard test nose-boom.

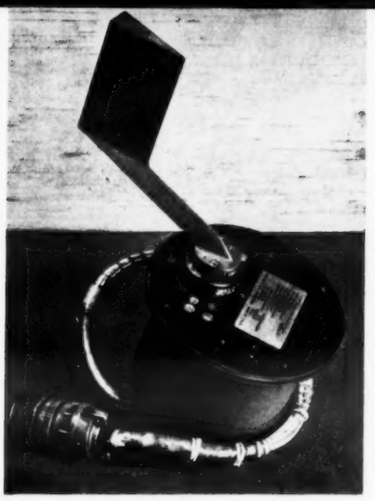


Fig. 8: Vane type angle-of-attack detector.

Fig. 9: Probe type angle-of-attack detector.

the pilot with an index for accomplishing the following for all altitudes and gross weight combinations:

1. Maximum endurance speed;
2. Best climb speed;
3. Best cruise speed;
4. Maximum distance glide.

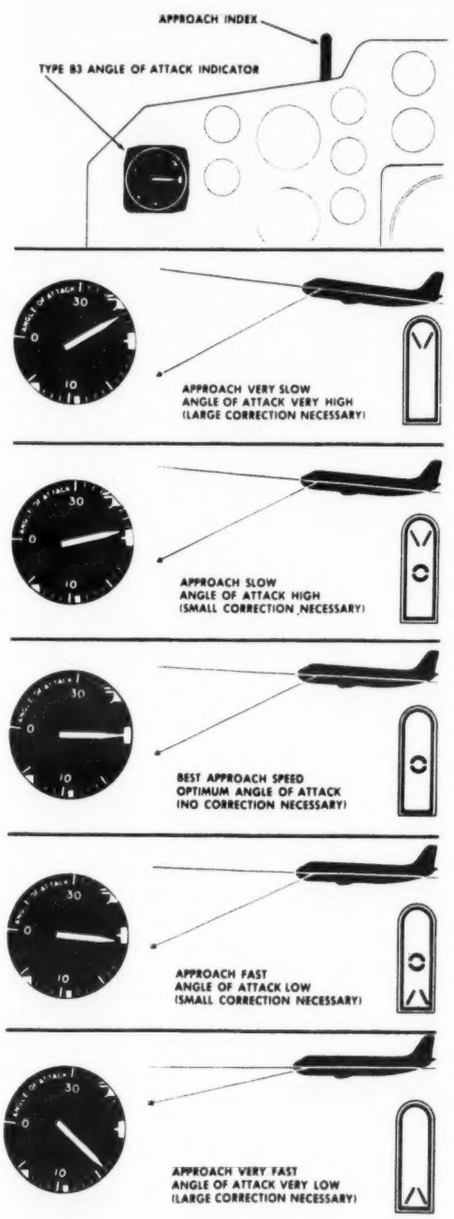
Very often items (2) and (3) are functions of engine performance as well as angle of attack. However, flying the angle of attack will allow operation at very near the correct speed, much nearer than can be accomplished by the present method of attempting to memorize the performance figures for all altitudes and weights. Items (1) and (4) are functions of C_L/C_D and are therefore directly related to angle of attack. It is evident that, if properly presented, the angle-of-attack indicator could become the most useful instrument in the cockpit.

Presentation and sensing devices

The presentation of angle of attack should be simple and direct. *Figures 5 and 6* are my recommendations for retrofit on standard instrument panels and futuristic vertical displays. I suggest that the dial type presentation be mounted near or in place of the airspeed indicator in the current "Sacred Six" arrangement.

In flight testing, the most successful means of determining angle of attack has been through the use of a nose-boom-mounted, mass-balanced vane (see *Figure 7*). Such an installation has satisfactory response and exhibits a minimum error but is a bit too vulnerable for use at an operational level. The two types which have been used to supply angle-of-attack information to fire-control systems during the past few years are shown in *Figures 8 and 9*. They are referred to as the "vane transducer" and "null-seeking probe" respectively. Both the vane type and the later versions of the probe are rugged and require little more care than the pitot tube of an airspeed system. The probe has better response characteristics in the low speed area than the vane, the latter being afflicted with lag and a tendency to overshoot.

Fig. 10: Type 83 angle-of-attack indicator and approach index on the instrument panel of a fighter *(Courtesy, Specialties Incorporated, U.S.A.).*



Some current NATO fighters utilize a dial type presentation plus an "approach index" (see *Figure 10*). I have flown this system and have found it to be an effective aid during a visual approach in that it relieves the pilot from some of the attention he must allot to the instrument panel when flying either an angle-of-attack or airspeed dial mounted on the instrument panel. The approach index should not be flown exclusively but rather as a means of alerting the pilot to the fact that a change has occured; he should then scan the angle-of-attack dial to determine the magnitude of the correction to be made. When fully understood and properly used, the "approach index" is a worthwile supplement to the angle-of-attack presentation.

Summary

As was previously stated, angle-of-attack instrumentation is not a revolutionary item; many pilots who have read this article have conducted evaluations of various systems during the past ten years. The results of the evaluations were not very gratifying. Most of these pilots are in agreement as to the potential value of angle of attack, especially as a landing aid. However, they were dissatisfied with the response, accuracy, flyability, and presentation of the systems they evaluated.

The lack of immediate success has created a false impression that angle of attack is of little value as a primary instrument. My own experience and that of many contacts during the past year has convinced me that angle-of-attack information is of great value to the pilot and, further, that there are systems available which perform well enough to warrant installation in all fighter aircraft.

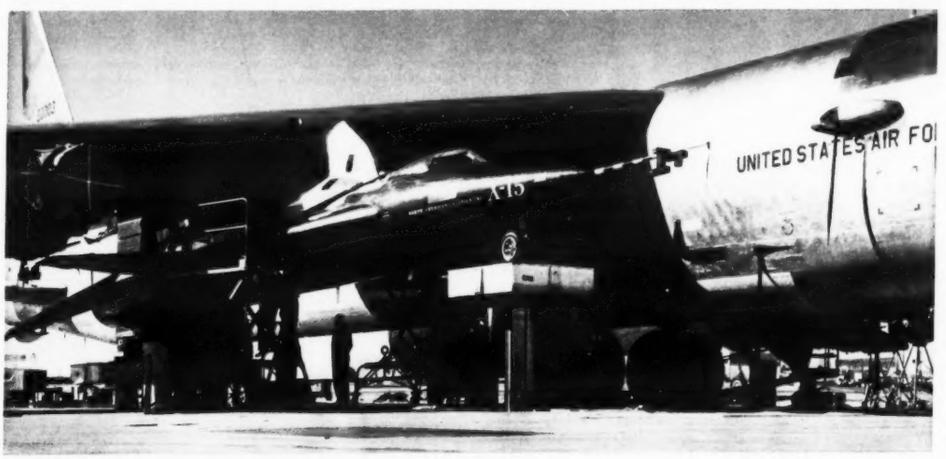
To accomplish safe operation of high-performance aircraft during the landing approach I suggest the installation of either the PMOLA or the Mirror Landing System on all runways. Where such all-weather systems as ILS are available, pilots should be encouraged to utilize them for all landing approaches. I favor the installation of an available angle-of-attack system in all fighters and recommend that such systems be further developed to the point where angle of attack may relegate airspeed to its proper role.

Pilots Beyond the Stratosphere

As these lines go to print the North American X-15 rocket-powered hypersonic research aircraft is just beginning its flight testing. It is therefore too early to report on the first flights and their results in the present issue. However, information culled from works publications and photographs supplied by the manufacturers have been combined to present the reader with a preliminary report on this highly significant event, which is expected to make an important contribution to the development of manned glide vehicles with global range. Editors.

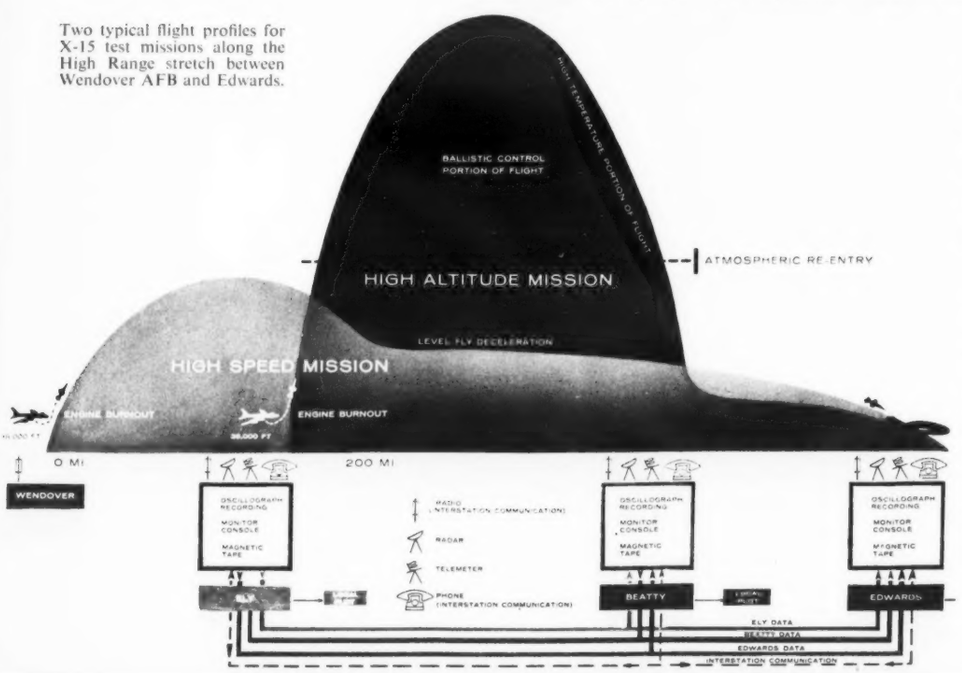
. . . Scott Crossfield, North American test pilot, has been waiting for this decisive moment for half an hour. Hermetically sealed off from the outside world, packed in a special, made-to-measure space suit and harnessed to a rocket ejection seat, he keeps his eyes glued on the X-15's instrument panel. In another few seconds his rocket aircraft will drop like a stone, gradually right itself and begin to respond to the controls. The altimeter in the eight-jet Boeing B-52 mother aircraft which has carried the X-15 under its starboard wing up into the stratosphere shows 38,000 ft. On a television screen the crew of the mother aircraft watches the X-15's pilot and his last "take-off" preparations. Crossfield has been sitting in the confined, profusely instrumented pressure cockpit of the rocket-like vehicle since the B-52 took off from the concrete runway at Wendover AFB. And now the great moment has come: for the first time a man is entrusting himself to a real space vehicle . . . even though on this first flight the X-15 is not to penetrate beyond the atmosphere, but merely to return to earth in an unpowered glide.

A button is pushed—the X-15 uncouples, drops faster and faster and begins on its long glide at high speed. The pilot has two minutes before he starts the landing manœuvre. Two decisive minutes, during which he and the North American engineers watching him must try and ascertain how the X-15 rolls and slips, how it reacts to the lowering of the flaps, how controllable it is about all three axes—for nobody has yet tested the steel airframe of this almost wingless craft in flight. True, the X-15 has been carried to great heights once before by the B-52, but only to check the aerodynamics of the under-wing suspension and the television link and voice communications between it and the mother aircraft.



The North American X-15 rocket research aircraft suspended on its pylon beneath the starboard wing of the Boeing B-52. It is raised into position by hydraulically operated platforms. The pylon contains connections for telephone and television cables, measuring-cable junction boxes and contacts for rocket propellant pipes.

Two typical flight profiles for X-15 test missions along the High Range stretch between Wendover AFB and Edwards.



Time is running out . . . in one minute Crossfield must be over a predetermined point at Edwards AFB, begin a wide circuit from an altitude of 20,000 ft. and then start on the most dangerous phase of the whole flight: the flare-out and touchdown on the dry salt lake. If he comes in either too high or too low, there is little chance of correcting his glide path . . . the X-15's approach speed is a full 240 knots.

Although the rocket-powered plane is equipped with the most accurate instruments ever installed in a manned aircraft, the success of the landing will depend almost entirely on the flying skill and judgment of the pilot. Admittedly Crossfield and other pilots have practised the manœuvre countless times on F-100 and F-104 fighters with airbrakes and brake parachutes out, or with engine cut, but the F-100 has at least proper wings. Even the F-104's wing is of presentable size compared with that of the X-15.

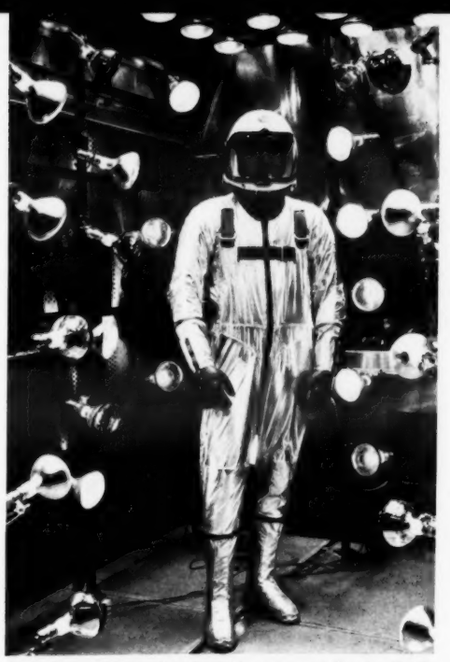
North American plans to carry out a total of twenty test flights, before handing the aircraft over to the USAF and NASA. Again and again use will have to be made of the room-size flight simulator which the manufacturers have had developed to simulate and check all the control functions in the new space aircraft. More than 2,000 "flights" have already been made by Crossfield and others on this electronic monster, to familiarize themselves with the X-15's whims. This is the first aircraft with three different control systems: an ordinary aerodynamic control system with conventional joystick between the pilot's knees, a second aerodynamic system with miniature joystick for wrist operation, and finally a ballistic control system (also with short joystick) which acts on jet nozzles on fuselage and wing tips during the ballistic phase.

Soon Crossfield will have the opportunity to acquaint himself with this part of the test programme. The first glide flight is to be followed by a high-altitude ride beneath the B-52's wing, without separation. This time the liquid oxygen tanks will be topped up by the mother aircraft during the climb, and the various components of this "in-flight refuelling system" tried out at altitude, after which the fuel and liquid oxygen will be jettisoned in flight. Finally, on the fourth mission, the rocket motor will be ignited.

Once the propellant tanks have been filled by the B-52, the rocket aircraft will immediately be dropped, whereupon the pilot will ignite the powerplant and carry out stability, controllability and load tests. The motor will then be shut off, re-ignited shortly afterwards and then kept constantly in operation until burnout. During this time the pilot must submit his craft to a searching check at all possible altitudes and attitudes. As the test programme proceeds, altitude and speed will be progressively increased, according to a flight profile worked out for each operation by an electronic computer. Two typical profiles are shown in the drawing on the previous page.

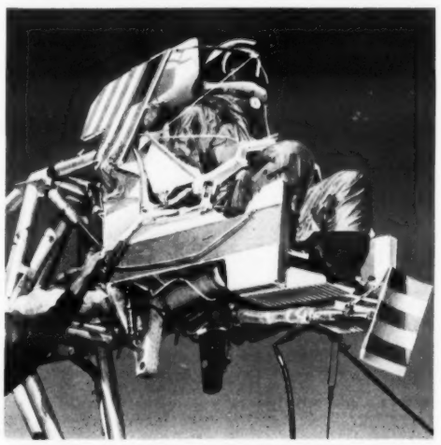
As the drawing indicates, the flight path from Wendover AFB to Edwards AFB passes over the High Range system of radar stations, special receivers and recording equipment, specially set up to permit accurate tracking of all X-15 flights. In addition, the gyro platform of the Sperry airborne inertial navigation system will record and transmit to the ground all movements made by the rocket plane. At the same time the speed, altitude and attitude readings from the inertial system will be precisely checked by means of ground tracking during the early flights. Even minor functional defects during the rocket-powered climb phase can lead to trajectory errors which would place the aircraft in serious danger at the end of the ballistic phase: if the re-entry angle were only a few degrees too steep, the X-15 would burn up like a meteor on penetrating the atmosphere again. Some idea of the complex nature of the planned testing is provided by the fact that during each test flight more than 1,000 measurements per second will be made on the airframe, most of them being transmitted to the High Range stations. In some cases this electronic "questioning" can be repeated as many as ten times a second. Of the ground engineer's 1,000 questions, 656 will be asked about temperature distribution over the surface and inside the airframe. Another 104 questions will deal with the strains placed on various parts of the aircraft, while pressure data will be received from 140 different spots.

The difficulties facing the X-15 designers will be discussed in a later issue. Even the equipment manufacturers involved in the programme as subcontractors had many a thorny problem to solve, as the following examples will show: General Electric was responsible for development of a turbine-driven auxiliary power source which operates all the aircraft's generators and supplies power to actuate the tail surfaces (the wing has no ailerons, but only flaps). This power unit had to be provided with an independent propellant system for hydrogen peroxide, which had to be space and weight saving and to operate like clockwork even under accelerations of 10g. Vapour from the hydrogen



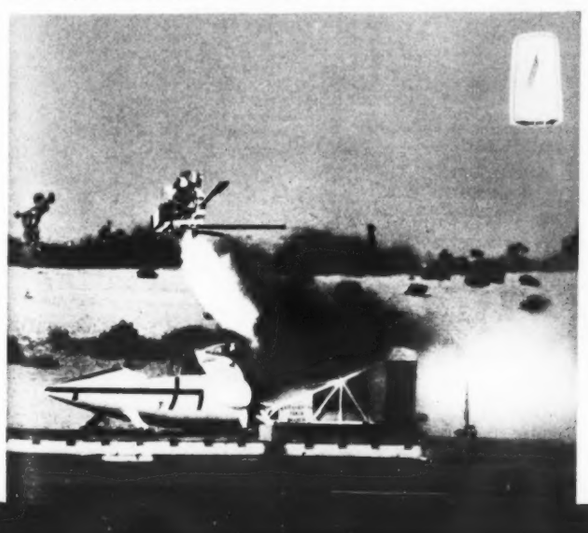
Scott Crossfield, packed into his space suit for the X-15, undergoes an infrared radiation cure.

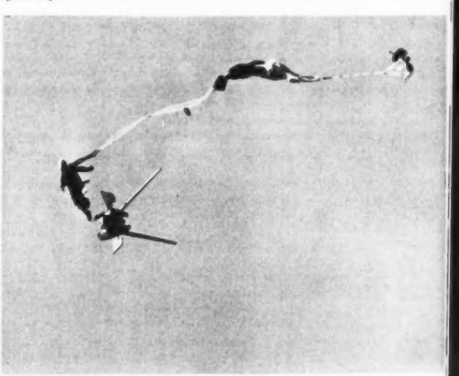
Stand-by pilot Al White tries on his made-to-measure pressure suit.



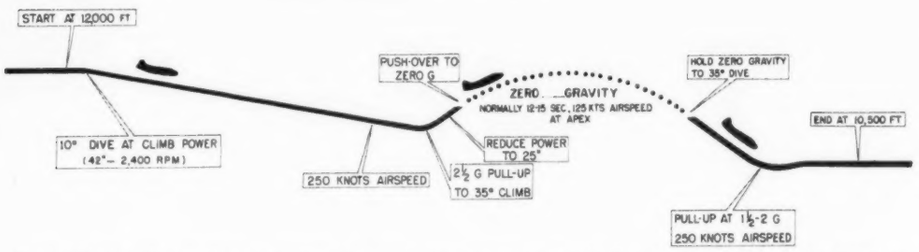
The X-15's rocket-powered ejection seat has stabilizing vanes on the side walls of the seat frame and a projecting shock wave plate which at supersonic speed produces a shock cone to protect the pilot.

On the rocket sled track at Edwards: the ejection seat is thrown out of the mockup of an X-15 fuselage nose. The rocket motor mounted underneath the seat propels the whole escape equipment obliquely upwards; pilot and parachute are automatically separated from the seat on reaching the apex of the trajectory.





Gravity has been overcome. Free floating demonstration in the cabin of the C-131B during zero gravity provoked by flying a Keplerian trajectory at an altitude of 10,000 to 11,000 ft.


START AT 12,000 FT
10° DIVE AT CLIMB POWER (42°– 2,400 RPM)
250 KNOTS AIRSPEED
PUSH-OVER TO ZERO G
REDUCE POWER TO 25°
2½ G PULL-UP TO 35° CLIMB
ZERO GRAVITY
NORMALLY 12-15 SEC., 125 KTS AIRSPEED AT APEX
HOLD ZERO GRAVITY TO 35° DIVE
PULL-UP AT 1½-2 G 250 KNOTS AIRSPEED
END AT 10,500 FT

Typical flight profile to achieve a Keplerian trajectory with zero gravity during 12 to 15 seconds. The mission begins at an altitude of about 12,000 ft. with a full-power dive, followed by a pull-up at 2½ g into a 35° climb. Then throttles are reduced, and the climb changes into a ballistic trajectory, with the aircraft falling weightless through the air until pulled out of the ensuing dive at an acceleration of 1½ g to 2 g.

The USAF Aero Medical Laboratory carried out the above tests in a C-131B converted by the Wright Air Development Center.

peroxide must also be fed to the control jets at the fuselage nose and wing tips*.

Westinghouse has the task of supplying a new-type stabilization system, which damps flight path oscillations and eliminates the dreaded combined roll and yaw movements which have doomed many a test pilot. Reaction Motors Inc., for many years suppliers of rocket motors for the X series of American research aircraft, was also entrusted with developing the X-15 powerplant, but met with many difficulties despite its long experience. The first prototype is fitted with a provisional 12,000-lb. thrust dual motor for alcohol and liquid oxygen (type designation XLE 11), but will later have the bigger XLR 99 with a thrust of 50,000 lb.

*

The greatest problems, however, were connected less with the robot systems than with the human occupant for the X-15. As the training programme for the pilots advanced, it became increasingly clear that the latest developments are beyond human endurance, and that it will be difficult to go on using man as a control organ with independent powers of decision. The price of creating an "artificial" environment for him aboard such craft and the weight of the equipment he needs may become prohibitive.

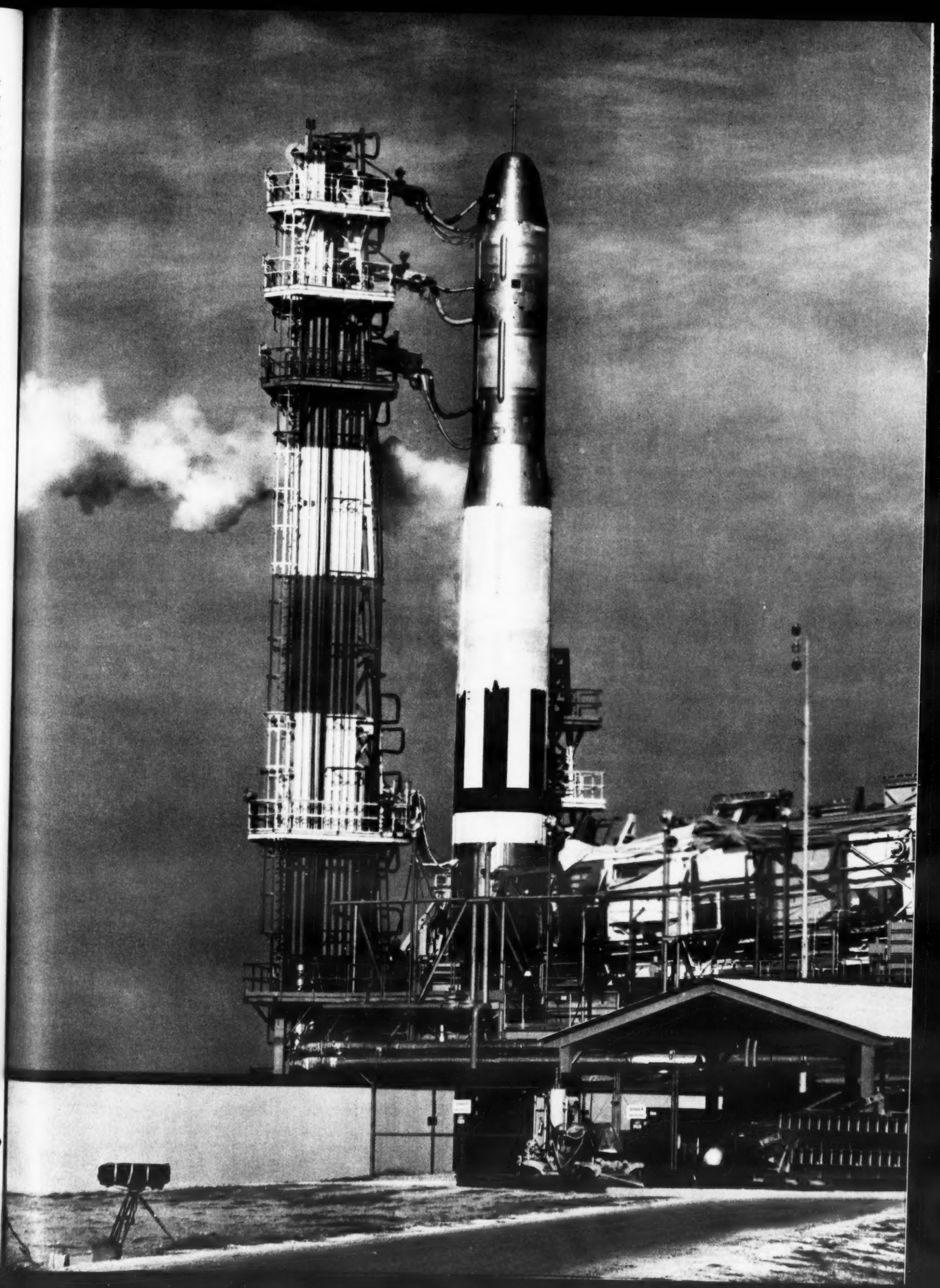
Not only were all likely pilots placed in the X-15 simulator mentioned above, but the entire cockpit system and control simulators were built into the Navy's big centrifuge at Johnsville, Pennsylvania. While the pilots were pressed into their seats with irresistible force, and their heads, arms and legs felt like lead weights, their hands and feet still had to perform control manœuvres and correct their "flight path". Next they were put into the heat and pressure chambers at the Aero Medical Laboratory, Wright Air Development Center, where, dressed in pressure suits, they were subjected to intense heat and intense cold. Reasons: during re-entry the walls of the pressure cabin will become red-hot, and in the event of having to operate the ejection seat in the stratosphere the pilot would be exposed to temperatures of minus 55 degrees Centigrade. A series of pictures in the present article illustrates the testing of the ejection seat on a high-speed rocket sled at Edwards. The vane-stabilized X-15 seat and its rocket-powered ejection mechanism would be worthy of a separate detailed report.

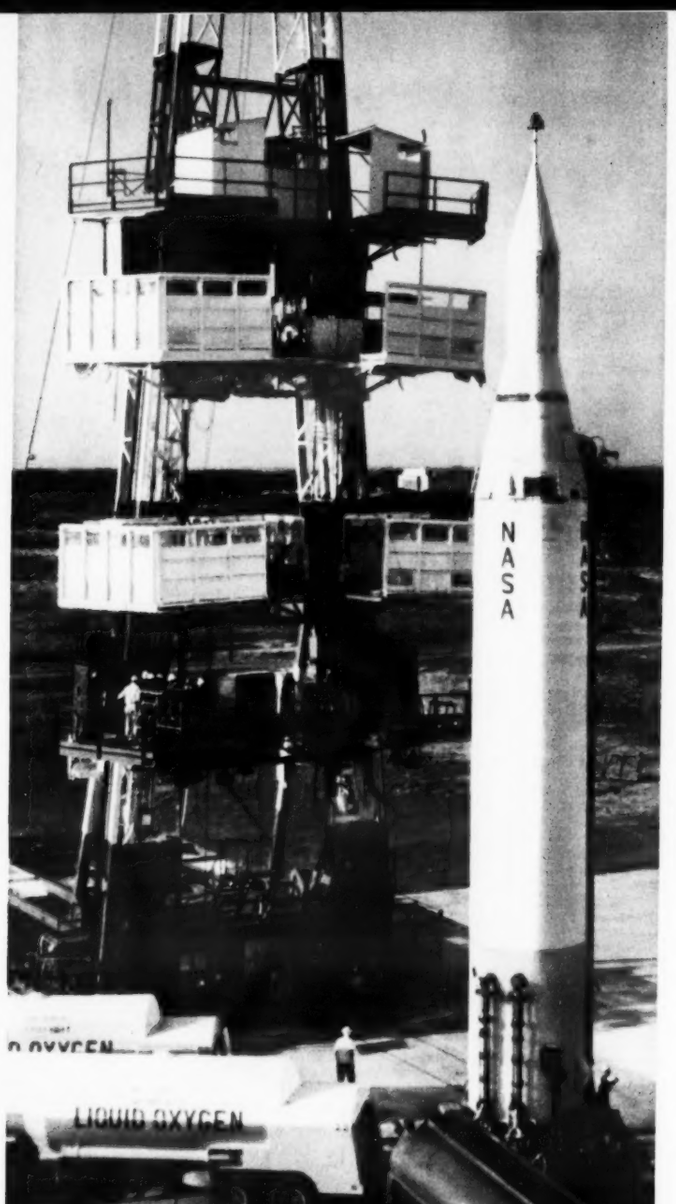
Finally, mention should be made here of an interesting series of experiments which the Aero Medical Laboratory has made on the behaviour of pilots under conditions of zero gravity. For these tests a modified Convair C-131B was used. After an initial dive followed by a pull-up at 2½ g, the aircraft was held on a Keplerian trajectory, remaining in a state of zero gravity for about 12 to 15 seconds near the top of the trajectory. The twin-engine Convair transport used is roomy enough (cabin length 25 ft.) to permit the carriage of extensive instrumentation and the simultaneous performance of several experiments. Similar tests had already been made with fighters, but the C-131B's installations enable much more systematic research to be carried out. Only a few years ago it was believed that the physiological effects of weightlessness would seriously endanger the human organism or at least make it temporarily incapable of action. This was a key problem in the X-15 programme. But all the experimental results so far achieved appear to contradict this view. No appreciable disturbances in motor performance were noted, and it is not considered necessary to alter the arrangement of levers or switches in the cockpit, provided the pilot is tightly strapped to a solid seat.

Millions of man-hours have already gone into the joint USAF and NASA programme. Further millions will be needed before global glide vehicles of the nature of the X-15 can come into operation for military or civil purposes. North American, however, is continuing its test programme with a view to handing over to the Air Force a proven research aircraft which can undoubtedly be described as the most revolutionary craft in U. S. aviation history.

A *Titan* two-stage ICBM shortly before launching at Cape Canaveral Missile Test Center. The Martin Company is prime contractor, and the powerplant is supplied by Aerojet-General. Both are working at full pressure to get the weapon ready for SAC.

* The fuselage nozzles deliver a thrust of 100 lb. in vertical and horizontal direction (for control about the vertical and transverse axes), and the wing-tip nozzles have 40 lb. thrust (for control about the longitudinal axis).





Fuelling the Army's *Juno II* carrier rocket a few hours before the launching of the *Pioneer IV* solar satellite.

Rockets, Missiles and

• Pioneer IV orbits the sun

The fifth test was successful. After four American space vehicles (three USAF and one Army) had failed to achieve their object of travelling beyond the moon into the solar system, it finally fell to the Army on March 3rd to attain the same kind of success as the Russians had scored with their *Mechta* solar rocket in the early days of January 1959.

The *Pioneer IV* space vehicle launched by the Army under the NASA programme escaped earth's gravitation with a velocity of 24,791 m.p.h., and on March 4th passed the moon at a distance of 37,000 miles with a speed of 4,525 m.p.h. on its way to the sun. According to NASA, the space vehicle will take 392 days to complete an orbit of the sun. The perihelion of the *Pioneer IV*'s orbit, reached on March 17th, was 91,744,000 miles distant from the sun; the aphelion will be about 105.829,000 miles from the sun, and will probably be reached on October 1st. It was originally planned to take the vehicle closer to the moon, but a slight trajectory angle error on burnout, detected first by Britain's Jodrell Bank radio telescope, led to a deviation of a few degrees. As a result of this error, which took the vehicle tens of thousands away from the point at which it was planned to pass the moon, it was not possible to carry out two of the planned series of measurements: detection of a possible radiation belt near the moon and the photoelectric recording of the journey past the moon. However, judging by events so far, the *Pioneer IV* can be described as a complete success for the Army and NASA.

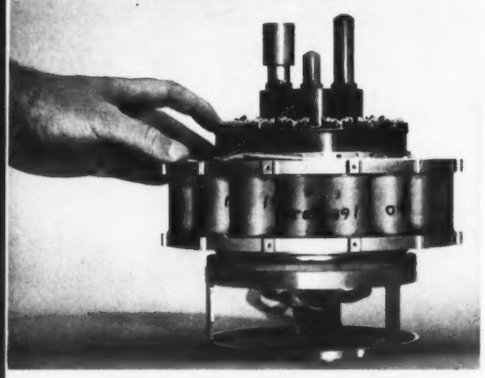
The four-stage vehicle, provided by the Army, was very similar to the *Juno II* carrier rocket used to launch *Pioneer III* (cf. *Interavia* No. 1, 1959, p. 74), and comprises a modified *Jupiter* IRBM as first stage, eleven clustered *Sergeant* solid-propellant rockets in a rotating drum as second stage, three more *Sergeants* as third stage, and finally a single *Sergeant* as fourth stage. The last stage carried the instrument payload which was later separated. The vehicle had an overall length of 76 ft. and weighed about 120,000 lb. on launching.

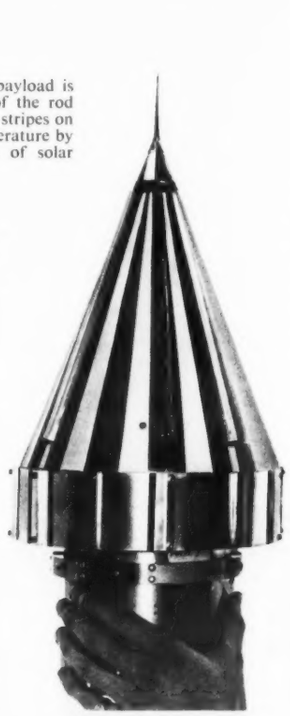
For stabilization purposes, the last three unguided rocket stages were spun rapidly immediately before launching at a speed gradually increased to 750 r.p.m. A few seconds after burnout of the first stage, which tilted the vehicle into the final trajectory, several coil springs were released by the ignition of explosive bolts, and the booster separated from the instrument compartment. This was followed by the firing of four small lateral kick rockets which caused the booster to slow down and move to the side, eliminating any possibility of the booster interfering with the flight of the separated upper stages. About one minute later, the nose cone of the shroud was removed by explosive bolts and springs, and a lateral kick rocket moved it to the side. Then the second stage of the upper assembly was ignited, and rotating at about 550 r.p.m. rapidly pulled out of the shroud, which contained the complete guidance system. The third and fourth stages were fired in quick sequence, and finally the conical instrument container was separated from the last stage by means of explosive bolts and coil springs. The burnt out final stage is now following *Pioneer IV* at an ever increasing distance on its space journey round the sun. Ten hours later the spin rate of the instrument cone was reduced to about 9 r.p.m. by a braking system consisting of fine wires and centrifugal weights. This was necessary to ensure proper functioning of the photo-electric recording equipment.

The *Juno II* and *Jupiter* IRBM inertial guidance systems are identical; the U.S. Army designation is Delta Minimum Inertial Guidance Scheme. Its method of operation is described by NASA as follows: "On the launching pad the rocket is first oriented in the general direction of the target. Then the small stabilized platform is aligned very precisely to the target. The rocket tilts and arcs through the sky, but the platform remains constant. Data for a pre-calculated trajectory are recorded on a tape in the guidance computer aboard the rocket. These instructions can be changed by remote control up to within 20 minutes of firing time, without opening the guidance system. Mounted on the platform are acceleration devices which measure with great accuracy any deviation that *Juno II* makes from the preset path, usually resulting from changes in wind direction and velocity." NASA adds

The plastic cover for the instrument payload is gold-plated to increase conductivity of the rod antenna at its tip. The black and white stripes on the cone are designed to regulate temperature by controlling reflection and absorption of solar heat.

Instrumentation payload for the *Pioneer IV*. The two larger tubes at the top are for radiation measurements; in the centre (surrounded by a circular set of dry batteries) is the transmitter; below it the lens of the photo-electric sensor for observation of the moon.

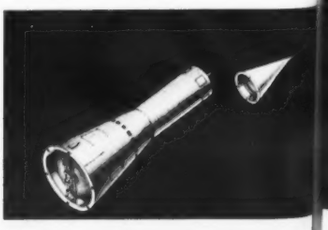




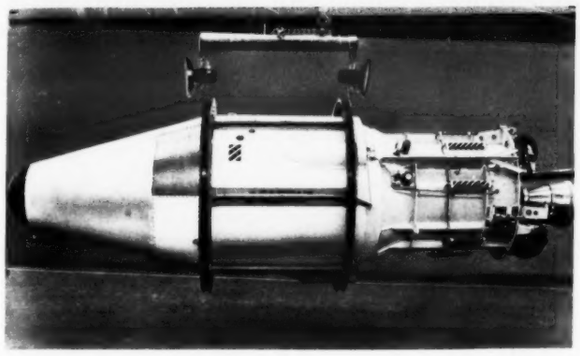
Ascent of the Juno II rocket:

Booster separation.

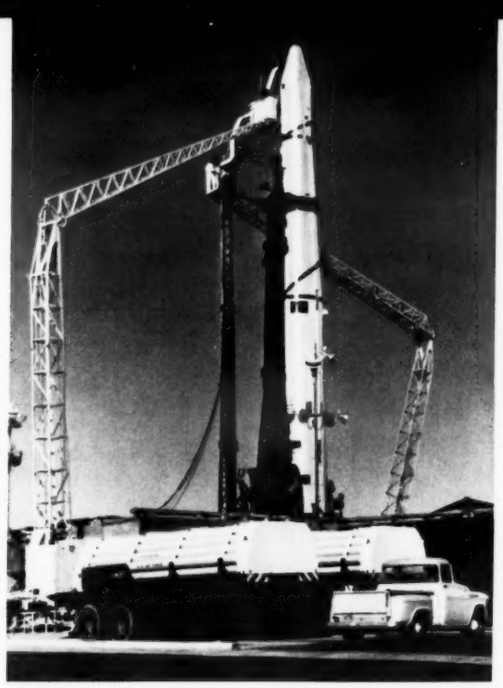
Separation of shroud.



Space Vehicles



Side view of the *Discoverer I* 19-ft. military polar satellite, consisting of the instrument payload (in the tip of the cone, left) and a Bell liquid-propellant motor.



Final preparations on the 100,000-lb. carrier vehicle for the *Discoverer* satellite.

• Discoverer I — first Polar satellite in orbit

The USAF launched its first *Discoverer* satellite from Vandenberg Air Force Base, California, on February 28th, 1959. The long-prepared firing had had to be postponed several times, but then the roughly 1,300-lb. *Discoverer* was successfully placed in a Polar orbit by means of a two-stage *Thor*/Bell rocket. Though the radio signals from the satellite have been received only sporadically (the transmitter works on an undisclosed frequency), presumably because of the vehicle's constantly changing attitude, it has been established that the orbit has an apogee of 519 miles and a perigee of 176 miles.

With the *Discoverer* satellites ARPA plans to test various components of projected USAF space weapons and in particular the operational methods for the WS 117-L *Sentry* observation satellite. Later *Discoverers* will carry experimental animals, which will be brought back to earth after a given time. The booster stage is a *Thor* IRBM, while the second stage, which also forms the satellite vehicle, is powered by a liquid-propellant rocket motor developed by Bell (for the weapons container in the Convair B-58 *Hustler*). Overall weight of the carrier vehicle plus satellite is 107,000 lb.

Tracking reports have been based on reception of signals from the satellite radio beacon for the most part, though some have been obtained from Doppler measurements and others by the Krause method of detection. The latter method, used by the General Electric tracking station at Ithaca, New York, is based on the reflection of signals by the ionization track of an object moving through outer space.

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that the vehicle's computer then compares the deviations with the programmed values and provides corrective signals which are converted, amplified and passed to the attitude control system in the first stage. This system actuates a number of variable thrust compressed air nozzles on the lower edge of the conical guidance instrument housing and swivels the booster rocket. Apart from the transmission of a radio signal for self-destruction of the carrier vehicle, there is no possibility of ground-to-rocket control. Guidance is carried out entirely by the magnetic tape control system, the computer and the gyro-stabilized platform.

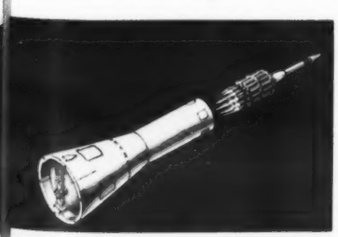
The actual space vehicle, that is the 13.4-lb. instrument package, is protected by a gold-plated cone, 20 inches long and 9 inches in diameter. It is similar to the instrumentation of the *Pioneer III* launched on December 6th, 1958, and carries a battery-powered 180-milliwatt radio transmitter designed to transmit continuously on a frequency of 960.05 megacycles for about 90 hours. A special device with germanium diode permits the continuous checking of the radio beacon's transmitted power, and was used to investigate a hitherto unknown phenomenon which apparently causes a damping of radio waves in space. Fading of the radio signals from the *Pioneer III* was continuously noticed, and was apparently not due to the vast transmission distance. Apart from this the instrumentation includes two Geiger-Müller measurement tubes, one of which is shielded with lead to cut out all but high energy radiation. The photo-electric sensor, also used in *Pioneer III* (two light-sensitive cells), remained out of operation, however, as it reacts only to a light intensity corresponding to less than 20,000 miles from the moon.

According to Dr. James A. Van Allen, Head of the Physics Department of the State University of Iowa, it was hoped to obtain information on the following problems from the measurement results of *Pioneer IV:* 1. the penetrability of radiation in space, and how much shielding will be required to reduce this to a tolerable level for any animal or human in space flight; 2. the detection and measurement of energetic solar gas ('hot plasma') passing the probe while in space (from such measurements during the first days, it was hoped to learn more on the so-called plasma radiation, which probably comes from eruptions on the sun); 3. another measurement of cosmic ray intensity in interplanetary space beyond the influence of the earth's magnetic field; 4. to find out whether the outer of the two radiation belts around the earth is more penetrating than the inner belt. This might give a clue as to whether the radiation in both belts comes from the same source; 5. to see whether the properties of the belts have changed since the *Pioneer III* flight.

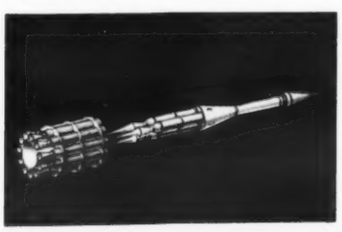
Army tracking stations at Cape Canaveral, Miami, Fort Stewart, Huntsville, Alabama and Aberdeen followed the probe during the first powered phase, lasting four-and-one-half minutes. The data were fed directly into the Computations Laboratory of the Army Ballistic Missile Agency, Huntsville, where a computer determined the deviations of the vehicle from the programmed trajectory. The second phase began five minutes after launch, and involved the following stations: the Jet Propulsion Laboratory tracking antenna at Mayaguez, Puerto Rico, JPL's 85-ft. diameter space tracking radio telescope at Goldstone Dry Lake in Camp Irwin, California, and finally Britain's giant radio telescope at Jodrell Bank. The Goldstone telescope is capable of receiving even weak signals from distances up to 400,000 miles from the earth, but due to the rotation of the earth, was unable to track *Pioneer IV* continuously. All the ground stations involved in tracking the probe reported good reception of signals from the vehicle's transmitters. Jodrell Bank received clear signals as late as March 6th, about 72 hours after launching; at this time the sun satellite was at least 370,000 miles away from the earth.

The *Pioneer IV* was the last of five space vehicles launched under the International Geophysical Year programme. The NASA programme for the coming fiscal year includes further launchings of experimental space vehicles designed to reach the moon, Mars and Venus.

Activation of second stage.

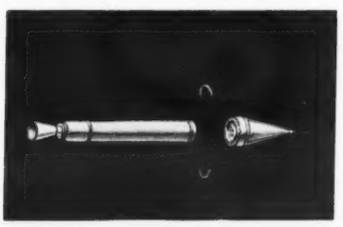


Ignition of third stage.



Ignition of fourth stage.

Separation of fourth stage from instrument payload.



What's in the Air?

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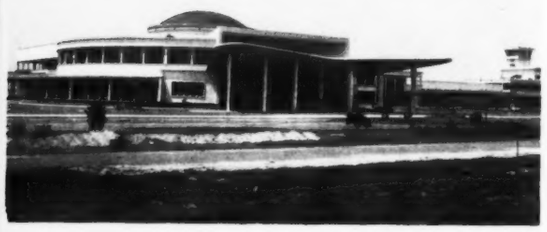
AIR TRANSPORTATION

● **The IATA Traffic Conference** meeting in Paris agreed the jet traffic fare differentials; the agreements reached cover what is essentially a transitional period from April 1st, 1959 to March 31st, 1960. The meeting approved the following measures: the introduction of surcharges on jet transport fares amounting to $15 on economy and tourist rates, and $20 on first class and deluxe rates, for all North Atlantic and mid-Atlantic services; a scale of surcharges to be applied to both first and tourist class fares to cover all international (e.g. New York—Buenos Aires sector) routes likely to be operated by jet aircraft in the area comprising North and South America; no surcharge to be applied in the eastern hemisphere (fares on Far Eastern routes had already been agreed at Cannes without the application of jet surcharges; North and Central Pacific jet operations had been similarly covered). Slight increases in passenger fares are to be applied to all services in certain areas, in order to offset rising operating costs (e.g. $5.00 for London—New York, or $7.00 for Paris—New York). Agreement was also reached on a wide variety of inclusive tour fares in Europe. Special rates are to be introduced for certain specified commodities on the North Atlantic services such as automobiles, agricultural machinery, chemicals, computers, etc. Basic cargo rates for certain areas were slightly increased (e.g. five percent in North Atlantic and Far East traffic).



The new N'Djili Airport at Leopoldville was opened in mid-February 1959 in the presence of Mr. Cornelis, Governor-General of the Belgian Congo, and G. Périer, Sabena's Chairman of the Board. Picture shows the terminal building.

● **The U.S. airlines** are showing concern about the increasing number of pilots past the 50-year mark who are still operating passenger transports. Federal Aviation Agency statistics show that in 1955 the number of pilots over 50 flying transport aircraft was 429, but in 1957 there were 521 pilots in this category. With the introduction of jet airliners, the airlines are now wondering whether pilots over 50 are psychologically and physiologically capable of their task. At the present, new test procedures to measure a pilot's overall competence for the job are being worked out. Most U.S. airlines set the pilot retirement age at 60, but medical experts are of the opinion that the new jet transports will require a lower retirement age. The Air Line Pilot's Association very rightly argues that the only basis for competency retirement should be competency tests, and not age alone.

● **Pan American World Airways** inaugurated an all-cargo service across the Pacific on April 1st, 1959. The service will be operated with Douglas DC-4s on a once weekly frequency departing San Francisco on Saturdays, with stops at Honolulu and Guam en route to Manila. Return flights will depart Manila on Wednesdays.

● **Continental Air Lines'** plans for the disposal of surplus piston-engined transports now cover a total of 14 transports which have been sold to Frederick B. Ayer Associates Inc. for a total of $5,250,000. Continental handed over three DC-3s and one Convair 340 last year, and a further five Convair 340s, three Convair 440s and two DC-6Bs will be handed over this year. The carrier has acquired 15 Vickers *Viscounts*, and will bring four Boeing 707s into operation this spring. In addition to these turbine-powered aircraft, Continental still has five DC-7Bs and one DC-6B.

● **New York Airways Inc.,** plans to purchase an initial five Fairey *Rotodyne* aircraft, at a cost of approximately $10 million. New York Airways President Robert Cummings has said that providing certain tests proceed satisfactorily the order will go through, and added that his company hoped to purchase an additional 15 *Rotodynes* at a later date.

● **Guest Aerovias,** the Mexican carrier, resumed flight between Mexico City—Miami—Lisbon—Madrid and Paris on March 20th, employing Douglas DC-6s recently purchased from Scandinavian Airlines System. Guest Aerovias has recently been reorganized with Mexican and Swedish private capital. Negotiations with SAS also provide for a technical assistance programme between the two companies.

● **The British Ministry of Transport and Civil Aviation** and the Air Registration Board have ordered interim modifications to be carried out to the dials of existing altimeters on the *Britannia, Comet, Viscount* and all other aircraft operating above 20,000 feet, to be completed by September 30th, 1959. The current instrument has three needles of varying length to register height in hundreds, thousands and tens of thousands of feet. The principal change is that the 10,000-foot needle has been lengthened and altered in shape to distinguish it from the other two pointers; it now reads directly on the extreme rim of the dial and is no longer obscured by other pointers.

● **Deutsche Lufthansa** will inaugurate regular services between Geneva and Frankfurt on May 24th, 1959, employing Convair 440 *Metropolitans* on a four-times weekly frequency (Sunday, Tuesday, Thursday, and Saturday). Arrival in Geneva is scheduled for 12:50 hours, and the return service to Frankfurt will depart Geneva at 19:15 hours. Incoming flights will continue from Geneva on to Nice, but will not be permitted to pick up passengers in Geneva. A preview of Lufthansa's 1959 schedules shows the following new services to be operated from Germany: Athens twice weekly; Milan daily; Manchester three times weekly; Barcelona three times weekly; Geneva four times weekly; Nice four times weekly.

● **Olympic Airways'** fleet strength has been increased by the hiring of a Douglas DC-6B, for an initial period of six months, from Scandinavian Airlines System. The Greek carrier's summer schedules, which came into effect on April 1st, 1959 include: Zurich—Athens five times weekly; London—Paris—Rome—Athens daily, with direct connections in Athens to the Middle East cities Istanbul, Beirut, Tel Aviv, Nicosia, Cairo and Khartoum. The Zurich—Frankfurt service will be operated five times weekly.

INDUSTRY

● **Canadair Limited** of Montreal (a General Dynamics Division) has been awarded an initial $1.7 million contract by Boeing Airplane Company for the manufacture of wings and ailerons for the *Bomarc* unmanned long-range anti-aircraft missile. This is the first time that a Canadian has participated in the production of an American missile. *Bomarc* bases in Canada will be coordinated by the North American Air Defense Command, with headquarters in Colorado Springs.

To mark the hand-over to the Belgian Air Force of the last Hunter *built in Belgium, Groupement Belge des Constructeurs de Matériel Aéronautique (GEBECOMA) organized an official celebration at the Fabrimétal premises. Left to right, André Dubuisson, Managing Director of SABCA, M. Buyse, Inspector General at the Ministry of Economics, G. Velter, Managing Director of Fabrimétal, Defence Minister A. Gilson, André Regout, President of GEBECOMA and Manager of the Fabrique Nationale d'Armes de Guerre, General B. E. M. Detige, Head of the Procurement Section at the Defence Ministry, General F. Burniaux, Chief of the Belgian Air Staff, Major General W. J. Reynierse, Head of the Procurement Section at the Netherlands Defence Ministry, H. During, General Manager of Fokker.*

General de Gaulle, President of the French Republic, visited the Sud-Aviation and Potez-Air Fouga plants in the Toulouse area in mid-February. Left of General de Gaulle is Georges Héreil, Chairman of Sud-Aviation.

● **Temco Aircraft Corporation** expects to dismiss over 2,000 Airframe Division employees by July of this year, as part of an overall shift in production from aircraft subcontract work to missiles and electronics. The personnel cut, which began in January 1959, is part of a master plan developed by Temco officials in 1956 to shift more than one-half of the corporation's entire sales into the missiles and electronics fields by the end of 1961.

● **Riddle Airlines** announces that the order for the Armstrong Whitworth AW. 650 *Argosy* freighter is for four aircraft.

● **Aerojet-General's** total sales for the fiscal year ended November 30th, 1958 reached the highest level in the company's history at $218,375,000, compared to $161,877,000 during 1957, an increase of 35 percent.

Profits after taxes were $6,028,000 compared with $3,818,000 in 1957, a gain of 58 percent. Earnings per share of common stock after Federal taxes and preferred stock dividends were $1.38 compared with 78 cents during 1957, on the basis of the 10 to 1 common stock split approved in March 1958. During the period, the company's payroll increased from 11,000 to over 17,000 and it is anticipated that 3,000 additional employees will be added by the middle of 1959.

AIRCRAFT AND EQUIPMENT

● **Costruzioni Aeronautiche Giovanni Agusta** has released first details of the new Agusta-Bell 102 helicopter: take-off weight 6,220 lb.; useful load 2,315 lb.; maximum speed 104 knots; cruising speed 86 knots; ceiling in horizontal flight 14,010 ft., or 9,220 ft. in vertical flight; maximum range 250 nautical miles. According to the latest information, the helicopter can take up to nine passengers.

● **Electronic Associates Inc.,** which has its European Regional Office and Computation Center in Brussels, has published a report entitled "Dynamic Analysis of an Aircraft Arresting Gear System". The report describes the simulation of an aircraft arresting gear system to be used in the recovery of naval aircraft on land when runway lengths are at a premium.

● **The SE. 3200 heavy helicopter** began static tests at Le Bourget airport on February 6th, 1959. Designed for both civil and military use, the helicopter can carry up to 18 passengers and is powered by three Turboméca *Turmo III* turbines all driving a single main rotor.

30,000 h.p.: eight Allison 501-D13 turbines await installation in Electras *at the Lockheed California Division.*

The Agusta-Bell 102 helicopter for nine passengers has commenced flight tests at Cascina Costa.

● **The Breguet 940** experimental STOL aircraft took off at a weight of 6.5 tonnes after a taxi run of 287 ft. during tests at Toulouse recently. Take-off distance to clear a 50-ft. obstruction was only 630 ft. The next series of tests is to be devoted to measuring the landing qualities.

● **The Max Holste company** has held a first Press demonstration of the new MH. 250 *Super Broussard* (two Pratt & Whitney R-1340 engines). This aircraft is now being fitted with the last items of equipment before beginning flight testing early in April. General Manager Max Holste described the reasoning behind the manufacture of the MH. 250 prototype, which is to culminate in the production of the MH. 260 version (with Turboméca *Bastan* turboprops) and the MH. 280 (Lycoming T53s). The fuselage of the turboprop versions will be lengthened by 4.33 ft., thus increasing passenger capacity from the normal 17 to 20 or 23.

● **Stark Flugzeugbau K.G.'s** engine division is offering a lightweight opposed-type engine for touring and sports aircraft, known as the Stamo 1400. The engine is now being type tested by the Deutsche Forschungsanstalt für Luftfahrt. The following characteristics are revealed: 4-cylinder 4-stroke engine; bore 3.15 in., stroke 2.91 in., swept volume 90.92 cu.in.; compression ratio 1:7.2; twin-magneto ignition; air-cooled; oil sump lubrication by means of central pump; 12-volt electric starter; pre-carburation heating; dry weight 128 lb.; power/weight ratio 2.85 lb./h.p. Performance: take-off rating 45 h.p. at 3,200 r.p.m.; maximum continuous rating 42 h.p. at 3,100 r.p.m. Price with electric starter DM 3,600.

● **The first of three Boeing VC-137A** jet transports will be delivered to the Military Air Transport Service in April, according to latest reports. The new aircraft will be added to the MATS Special Air Mission fleet. The VC-137A is identical to Boeing's Model 707—120 series in all but two respects: interior layout and electronics equipment.

● **A Nord Griffon 02 experimental aircraft** (fitted with a SNECMA *Atar* turbine and Nord-Aviation ramjet) set up a new world speed record over 100 km on February 25th, 1959. The aircraft achieved a speed of 1,019 m.p.h.; the precise figure will not be known until the recordings have been evaluated. The record flight was made at an altitude of 22,970 ft.; radar equipment was used to track the aircraft's flight path.

● **The first Victor B.2 bomber** flew from the Handley Page airfield at Radlett, Hertfordshire, for the first time on February 20th, 1959. The aircraft is powered by four Rolls-Royce *Conway RCo.11* engines of 17,250 lb. thrust each. The B.2 is thus the first production aircraft to fly with the *Conway* installed. The Victor B. 2 has extended wings, enlarged intakes, and retractable airscoops on either side of the rear fuselage containing ram-air turbines for emergency power at high altitude. A Blackburn-Turboméca *Artouste* is installed in the starboard wing to provide low altitude emergency air. On the ground, air from the *Artouste* acts as starter for the starboard *Conways*. The B.2 can utilize under-wing tanks for extended range, and it is believed that the *Blue Steel* stand-off bomb can be totally submerged in the weapons bay.

● **According to a release by Convair,** who has received a subcontract for manufacture of wings for the North

Dewey-Shepard Boiler Co., Peru, Indiana, is operating a Vampire *jet fighter bought from the Royal Canadian Air Force as an executive aircraft.*

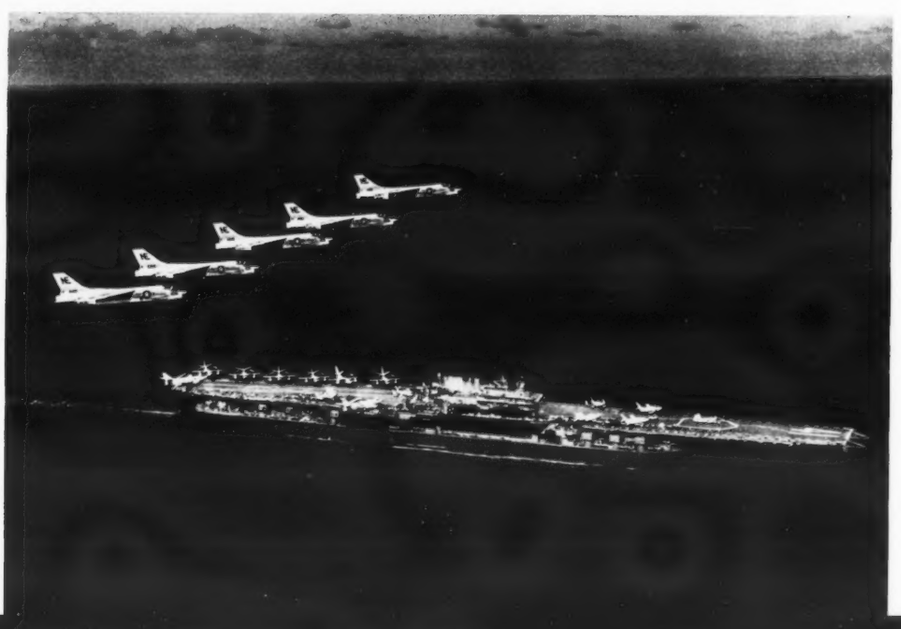
The planned CL-44G version of the Canadair CL-44 transport, which is to be equipped with Rolls-Royce Tyne *turboprops. The CL-44G can carry a max. payload of 62,000 lb. over a range of 1,900 nautical miles.*

Fitting a Rolls-Royce Conway *engine into the first Boeing 707-420 destined for BOAC.* Conway *engines are also to be fitted in the 707-420s on order by Lufthansa, Air-India International and Varig.*

A new version of the Saab-35A Draken *is in production. It has a longer rear fuselage and retractable tail-wheel instead of the earlier bumper. The lengthened rear fuselage reduces drag at supersonic speed, while the tail-wheel facilitates landing with high nose position for aerodynamic braking.*

Pakistan Shell Oil Company Limited is operating a specially equipped Catalina *amphibian aircraft for oil prospecting in the Bay of Bengal. The aircraft and crew were chartered from World Wide Helicopters Ltd., Paris.*

Parade of Amsterdam-Schiphol's airport fire service.



Five Chance Vought F8U-1 Crusaders *over the American USS* Midway *aircraft carrier in the Pacific.*

American F-108 long-range interceptor, the new aircraft is a twin-engine, two-seat model. Operational altitude is reportedly 60,000 ft., and radius of action at least 870 nautical miles.

● **The Pratt & Whitney J60** lightweight jet engine (hitherto known as the JT-12) is also to be fitted in the production model of the North American T-39 *Sabreliner* twin-engine multi-purpose aircraft and USAF trainer. The J60 was recently selected for the Lockheed *JetStar* and for the four-jet McDonnell 119; it is also used in certain Republic and Fairchild target drones. A first production T-39 fitted with the J60 is expected to be completed early in 1960. It will be recalled that a prototype of the T-39, with J85 engines, has been undergoing flight tests since last September.

● **Piper Aircraft Corporation** plans to market a new two-seat sports and multi-purpose aircraft, the Papoose, at a price of $4,000 to $5,000. At the moment the manufacturers are engaged in extensive market research and are working on first designs for the new model. This will be a low-wing monoplane with side-by-side seats; fixed nose-wheel undercarriage; 90 to 100 h.p. engine.

● **Two research contracts** amounting to approximately $175,000 are reported by Cornell Aeronautical Laboratory, Buffalo, N.Y., under sponsorship of the Army Transportation Research and Engineering Command. One contract provides for aerodynamic research on the various configurations which have been proposed for VTOL-STOL aircraft. The other calls for the development of a flight test programme which will provide a thorough engineering evaluation of the various models of vertical take-off aircraft now under development for the Army.

● **De Havilland Aircraft of Canada** announces changes in dimensions and weight of the DHC-4 *Caribou* which will improve payload and carrying capacity, while still retaining the short take-off and landing performance. The decision to make these modifications came after six months of test flying with the first two aircraft, in which time nearly 400 hours of flying have been performed. Gross weight of the DHC-4 has been increased from 24,000 to 26,000 lb., which provides a greater payload. The aircraft will be certificated at this increased gross weight and will fully meet the requirements of CAR Part 4B. To better accommodate the bigger load, the cabin has been lengthened by some 45 in. to 28 ft. 9 in., providing space for another row of passenger seats (total of 30 seats). Cargo capacity is similarly increased.

● **A new version of the twin-engine Avia 14,** with special equipment for geological research from the air, is announced. Omnipol, the State trading organization in Prague, also reports that Czech-built Avia 14s are now in service on the air transport networks not only of Czechoslovakia, but also of the USSR, China and Indonesia.

● **Two prototypes of the new Aer Lualdi L. 59** (260-h.p. Continental 10-470-D with direct fuel injection) are at present being constructed under an Italian Armed Forces contract at Aeronautica Macchi's Varese plant. Aer Lualdi announces that the L. 59 will also be demonstrated in flight at the Paris Air Show at Le Bourget in June this year. It is planned to commence production of a batch of 50 helicopters in September 1959. First details of the L. 59, which is derived from the L. 57, have been released: the main rotor blades are of all-metal construction; the four-seater is equipped with dual controls; accommodation for two stretchers, etc. Weights: weight empty 1,390 lb.; maximum take-off weight 2,425 lb.; take-off weight with overload 2,535 lb. Typical flight performance at 1,870 lb. take-off weight: ceiling with ground effect 14,750 ft., or 11,150 ft. without ground effect; maximum ceiling 19,360 ft. Ceiling at 2,425 lb. take-off weight 9,510 ft. with, or 5,580 ft. without ground effect; maximum ceiling 12,800 ft. Ceiling at 2,535 lb. take-off weight, with ground effect, 6,560 ft.; maximum ceiling 9,840 ft. Cruising speed 87 m.p.h.; maximum speed 100 m.p.h. Rate of climb 1,250 f.p.m. at 1,870 lb. take-off weight, or 820 f.p.m. at 2,425 lb. take-off weight.

● **The McDonnell 119** four-jet general purpose aircraft (training, VIP transport, etc.) began flight testing at the beginning of February. For its first flights it is still powered by down-rated Westinghouse J34s, but this engine is later to be replaced by the Pratt & Whitney J60 (JT-12). It is espected that the J60s will be delivered around October this year. Provisional data released for the McDonnell 119: cruising speed at least 430 knots at altitudes of approximately 40,000 ft.; range roughly 1,900 nautical miles.

28 DECCA RADARS FOR FRANCE

DECCA RADAR

Accurate wind and weather information is vital to the safe and economic operation of modern aircraft.

The Météorologie Nationale are equipping all their principal meteorolcgical stations in France and the French Union with Decca Windfinding and Weather Radars.

Decca Radar are proud to be associated with this advanced project, and wish to acknowledge the co-operation of the Météorologie Nationale and other meteorological authorities throughout the world in the development of equipment to satisfy the stringent needs of the modern meteorologist for simple, economical, reliable and accurate observing instruments.

Decca Meteorological Radars are being manufactured in France by La Société d'Optique, de Mécanique, d'Electricité et de Radio.

40 Meteorological authorities use Decca Windfinding and Weather Radars.

DECCA RADAR LIMITED LONDON · ENGLAND

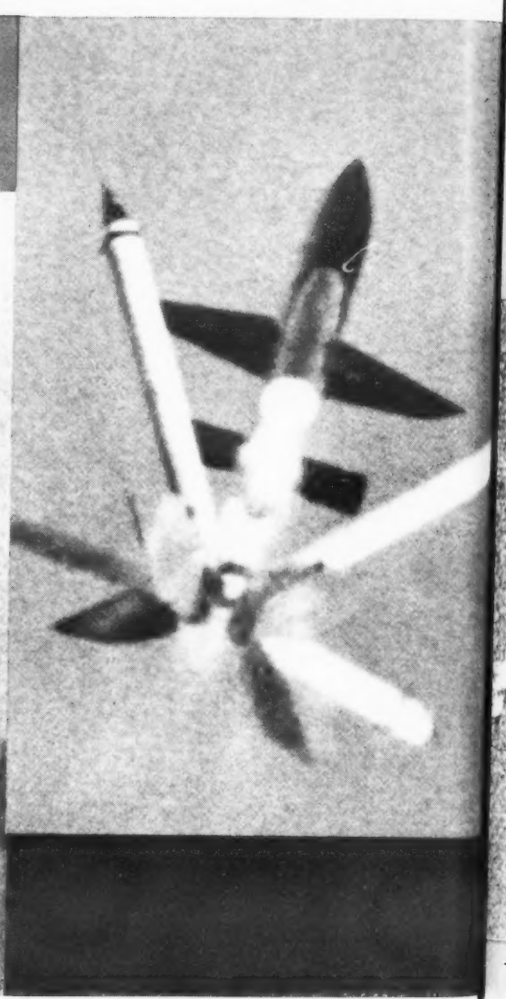
DR 90

EFFECTIVE

Bloodhound Weapon System

Missiles and launchers readily transported on light limbers; rapid installation on site

Launching, assisted by rockets; main ramjets burn safe-to-handle kerosene

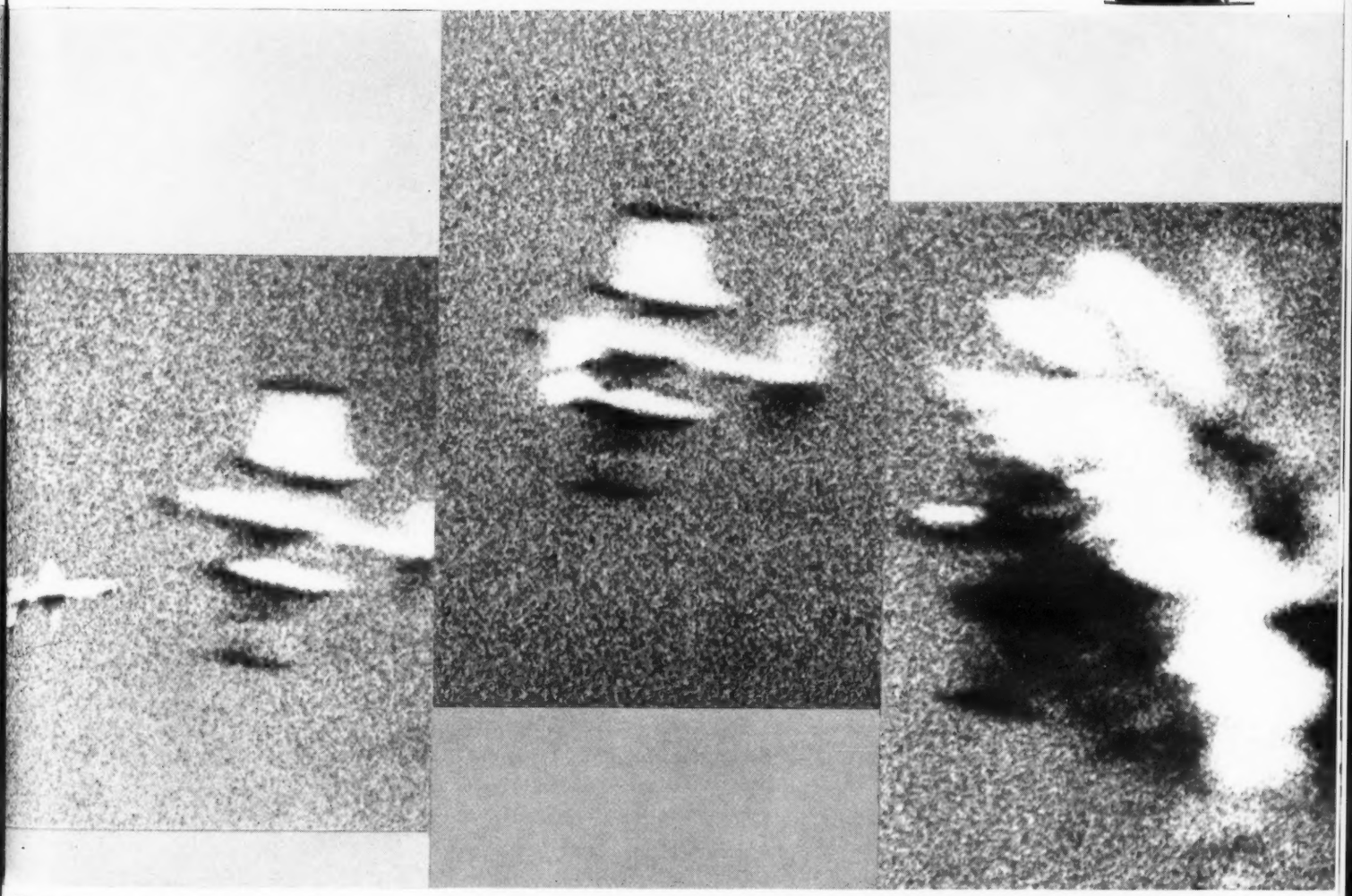


Rockets jettisoned; ramjets, started easily from cold, already giving even more speed

Approaching full operational status with the RAF as mainstay of Britain's air defence . . . proved in many hundreds of test firings . . . adopted by Sweden after exhaustive consideration of surface-to-air guided missile systems available throughout the world . . . Bristol/Ferranti Bloodhound forms the world's most effective defence system now and for many years to come.

DEFENCE

adopted by Britain and Sweden



Missile homes on to target; semi-active guidance system ensuring highest accuracy

Missile closes in; moving wing control holds course, whatever evasive action target takes

Missile gets within lethal distance; proximity fuse detonates warhead—target destroyed

Security forbids publication of full details, but the following facts about Bloodhound can now be given:—

Power. Each Bloodhound missile has two Bristol Siddeley ramjets —jet engines with no moving parts. Ramjets ensure power and range flexibility, burn kerosene, are simple and safe to handle.

Homing System. Semi-active: i.e., ground crew directs radar beam on to target; radar echo received by Bloodhound missile, ensures highest accuracy—regardless of range. Missiles may be fired, singly or in salvoes, using only one radar.

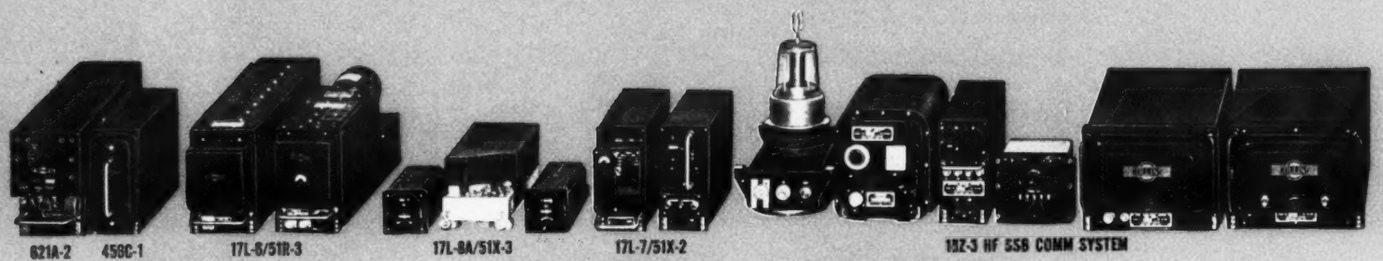
Airframe. Employs unique and advanced monoplane moving wing configuration. Advantages: quicker and more precise response; greater accuracy of interception; superior at high altitudes. This configuration was selected at initial design stage to embody maximum development potential.

BRISTOL/FERRANTI

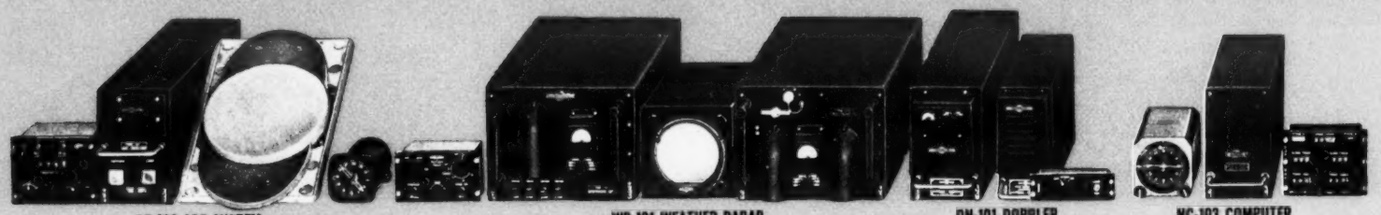
Bloodhound

GUIDED WEAPON SYSTEM

WEAPON DESIGN AND CONSTRUCTION BY BRISTOL · GUIDANCE AND CONTROL BY FERRANTI · SYSTEM SALES ORGANISATION BY BRISTOL AIRCRAFT LIMITED

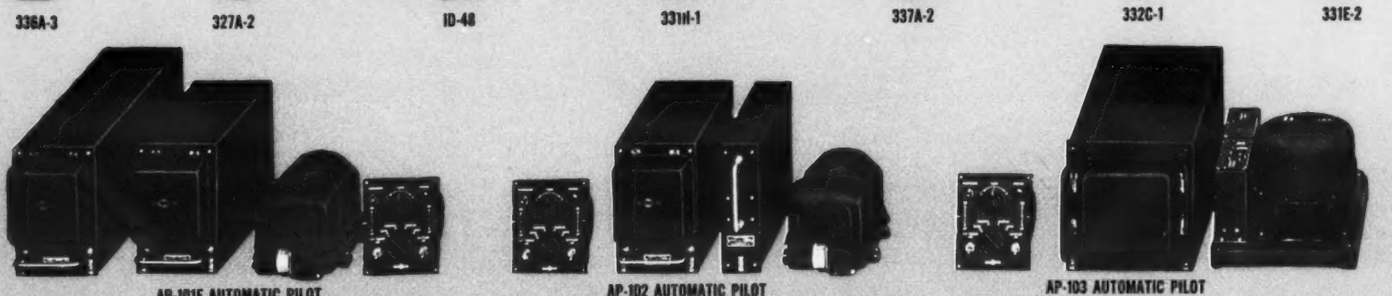


621A-2 456C-1 17L-6/51R-3 17L-8A/51X-3 17L-7/51X-2 18Z-3 HF SSB COMM SYSTEM



DF-202 ADF SYSTEM WP-101 WEATHER RADAR DN-101 DOPPLER NC-103 COMPUTER

336A-3 327A-2 ID-48 331H-1 337A-2 332C-1 331E-2



AP-101E AUTOMATIC PILOT AP-102 AUTOMATIC PILOT AP-103 AUTOMATIC PILOT

Collins...the greatest line in

COMMUNICATION

621A-2 TRANSPONDER — Reinforces radar replies to ATC radar beacon. Side lobe suppression limits response to main lobe of radiation pattern. Ceramic disc-seal transmitting tube. 1/2 ATR case. Transponder wt. 26 lbs.

456C-1 SELCAL — Twelve resonant reed relay assemblies in each of two channels in 3/8 ATR short case. Switches on front panel ease code selection. Selcal wt. 10.25 lbs.

17L-4, -6/51R-3 VHF COMM SYSTEM — Transmitter has 360 channels, 118-135.95 mc, 50 kc spacing, 25 watts output. 51R-3 provides 280 channels, 100 kc spacing, 108.0 to 135.9. System wt. approximately 65 lbs.

17L-8A/51X-3 VHF COMM SYSTEM — Lightweight 3 watt 90 channel transmitter, 180 channel receiver and power supply. Crystal controlled. 17L-8A tunes from 118.0-126.9; 51X-3 from 108.0-126.9. 100 kc increments. System wt 10.75 lbs.

17L-7/51X-2 VHF COMM SYSTEM — Airline standard. 17L-7 provides 25 watts output on 680 channels between 118.0 and 151.95. 51X-2 reception on 880 channels between 108.0 and 151.95 kc. 50 kc spacing. Crystal control. System wt. 27 lbs.

18Z HF SSB COMM SYSTEM — Fully automatic SSB communication on 28,000 channels, 2-30 mc in 1 kc steps. 1 kw PEP. System includes Receiver-Exciter, Power Amplifier, one or more Remote Controls. Antenna couplers available.

618T HF SSB COMM SYSTEM — Fully automatic SSB communication on 28,000 channels, 2-30 mc in 1 kc steps. 400 watts PEP. System wt. approximately 50 lbs.

18S-4 HF COMM SYSTEM — Self contained transmitter receiver. Has associated automatic tuner. Up to 20 crystal controlled channels, 2-18.5 mc with 100 watt output.

618S HF COMM SYSTEM — Transceiver offers up to 144 crystal controlled channels in 2-25 mc range. 100 watt output. Has associated antenna tuner and power supply.

346A-1 INTERPHONE AND ISOLATION AMPLIFIER — Provides interphone, isolation and speaker amplifier functions. Wt. 7 lbs.

346D-1 PASSENGER ADDRESS AMPLIFIER — Transistorized high fidelity amplifier. Inputs for pilot, stewardess and tape reproducer. Multiposition tone control. Wt. 9.6 lbs.

NAVIGATION

DF-202 ADF SYSTEM — Includes 51Y-3 Receiver. Silicon diodes, dry disk rectifiers and transistors hold tube count to 11. Digital frequency presentation on Remote Control. Tunes 90 to 1800 kc in four bands. Flush or semiflush mounted antenna. Integral power supply. System wt. approximately 31 lbs.

WP-101 WEATHER RADAR — Pulse modulated operation in the C-band 5400 mc frequency range. Ranges, 20, 50, and 150 miles. Bright tube indicator allows daylight viewing without hood. Offset sweep presentation.

DN-101 DOPPLER RADAR NAVIGATION SYSTEM — FMCW SSB techniques used to enable operation from 0 to 50,000 ft. Effective operation over smooth seas. Provides continuous indication of drift angle and ground speed. Dual system operates from single antenna. Equipment can be ground tested. Low power consumption. System wt. approx. 65 lbs.

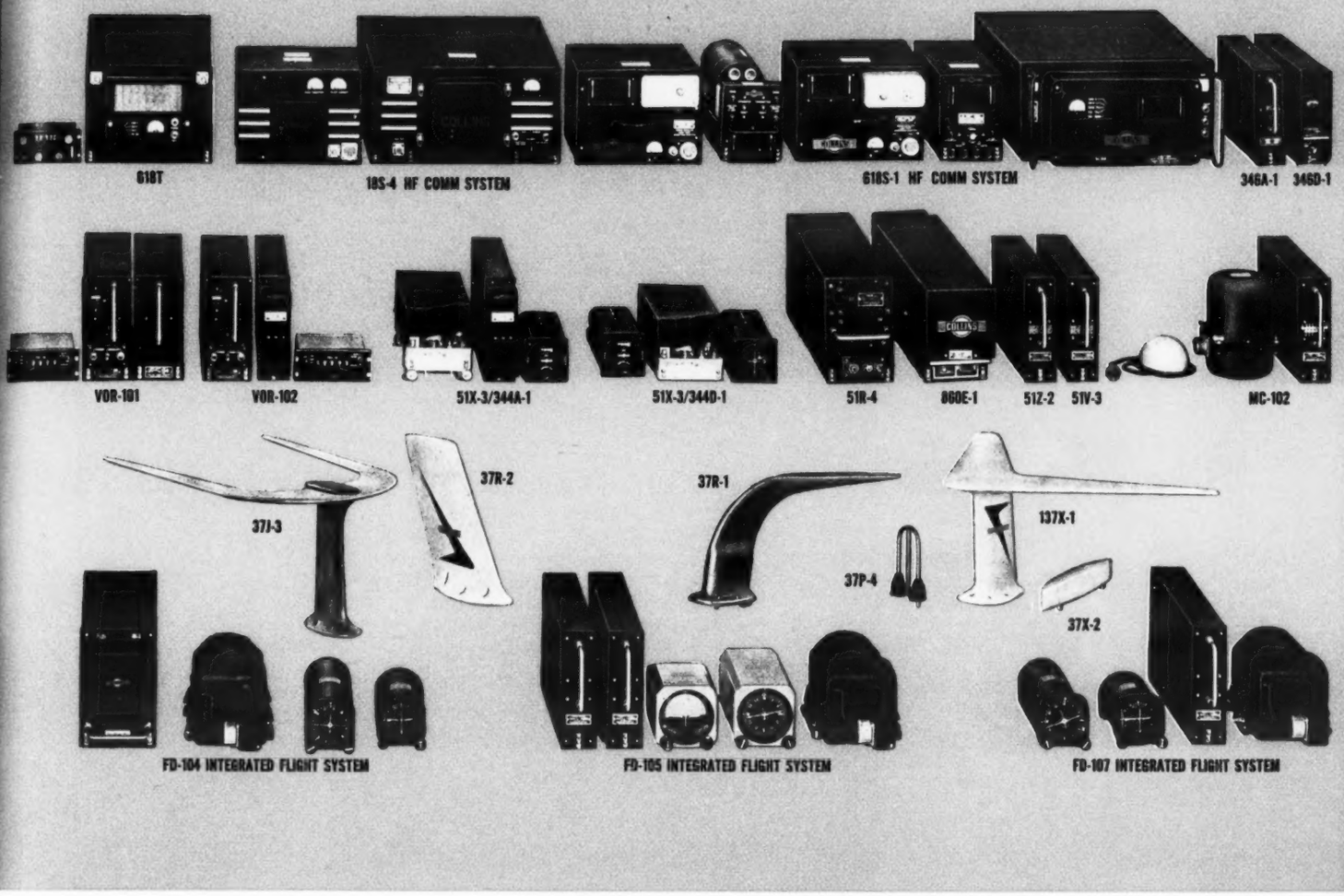
NC-103 DOPPLER NAVIGATION COMPUTER SYSTEM — Processes DN-101 ground speed, drift angle and compass inputs and presents along-track and across-track information to a read-out control panel. Supplies output data to course line deviation indicator, distance display and automatic pilot. System wt. 23 lbs.

VOR-101 VHF NAVIGATION SYSTEM — 51X-2/344B-1 combine to provide 880 channels with 50 kc spacing between 108.0 and 151.95 mc. Visual localizer, omnicourse, glide path to-from, OBI and RMI outputs in addition to voice reception. System wt. 24.5 lbs. Integral power supplies.

VOR-102 VHF NAVIGATION SYSTEM — 51X-2/344A-1 combine to provide same services as VOR-101 except no RMI service is available. 3/8 ATR short and 1/4 ATR short cases. System wt. 19.5 lbs. Integral power supplies.

51X-3/344A-1 VHF NAVIGATION SYSTEM — Lightweight deluxe navigation system with all services except RMI. System wt. 17.9 lbs.

51X-3/344D-1 NAVIGATION SYSTEM — Two panel mounted 3" cases provide VHF reception and left-right VOR/LOC indication, reciprocal bearing, to-from information and VOR course selection. Associated power supply with included shockmount. System wt. 13.15 lbs.



Ever since the early days of commercial aviation the prestige of Collins communication and navigation equipment has thrived, nourished by an energetic research and development program dedicated to the advancement of aviation electronics. The result is evident on these pages – the most complete line of high quality avionics equipment bearing one trademark. And even this group portrait is incomplete, lacking the scores of servos, remote control units, shock-mounts and test equipment associated with the major systems pictured. The Collins name is as important in military as it is in commercial aviation. In addition to the Collins communication and integrated electronics systems serving jet fighter and bomber squadrons throughout the world, Collins airline type equipment is widely used aboard military transports.

avionics

COLLINS

COLLINS RADIO COMPANY • CEDAR RAPIDS • DALLAS • BURBANK

51R-4 VHF NAVIGATION RECEIVER — Utilizes the same modules and provides the same services as the VOR-101. 1/2 ATR case offers optional size for identical service. Wt. 23 lbs.

860E-1 DMET — Provides precise distance information for aircraft up to 200 nautical miles from associated ground beacon. Provides 1 kw min. peak pulse power. Wt. 35 lbs.

51Z-2 MARKER BEACON RECEIVER — One or three light and aural indication of passage over 75 mc marker beacon. Completely transistorized. 3-light version, wt. 4.9 lbs.

51V-3 GLIDESLOPE RECEIVER — Motor driven crystal switch for frequency selection of 20 channels between 329.3 and 335.0 mc. 10 channel version is available. Flag alarm circuit included. 1/4 ATR short case. Wt. 6.3 lbs.

MC-102 MAGNETIC COMPASS SYSTEM — Lightweight gyro-stabilized compass with output power to drive an automatic pilot, flight director, Doppler and other navigation systems. System wt. 13.8 lbs.

INSTRUMENTATION

346A-3 OMNI-BEARING SELECTOR — Enables selection of desired track and provides to-from information. Wt. 2 lbs.

327A-2 MARKER LIGHT INDICATOR — Contains three press-to-test lights and Hi-Low sensitivity switch. Wt. 0.63 lbs.

ID-48 DEVIATION INDICATOR — VOR/ILS displacement data. Flag service. Wt. 1.9 lbs.

331H-1 COURSE SELECTOR INDICATOR — Provides cross-pointer, to-from, flag and digital course selector service. Wt. 4.0 lbs.

337A-2 OMNI-BEARING INDICATOR — Presents true bearing to VOR station and drives RMI pointers. Wt. 2.5 lbs.

332C-1 RADIO MAGNETIC INDICATOR — Dual input for VOR or ADF. Provides heading and omni or ADF bearing. Wt. 2 lbs.

331E-2 ADF INDICATOR — Similar to 332C-1 indication except no magnetic heading indication. Variation set knob sets card. Wt. 1.5 lbs.

ANTENNAS

37J-3 VOR NAV ANTENNA — Receives VOR and LOC signals in the 108-122 mc range. Drag of 2.6 lbs. at 250 mph. Wt. 4 lbs.

37R-2 VHF COMM ANTENNA — Receiving and transmitting antenna with maximum input capability of 125 watts. Frequency range: 116-152 mc. Drag of 0.5 lbs. at 250 mph, 1.3 lbs. at 400 mph. Wt. 2 lbs.

37R-1 VHF COMM ANTENNA — Receiving and transmitting antenna in 118-136 mc frequency range. Drag is 1 lb. at 250 mph. Wt. 3.5 lbs.

37P-4, -5 GLIDESLOPE ANTENNA — Accepts glideslope signals in the 329-336 mc range. Negligible drag. 37P-5 has two inputs for dual glideslope receiver installation. Wt. 0.7 lbs.

137X-1 VHF COMM/NAV ANTENNA — Combined unit for communication from 118 to 136 mc and navigation from 108.0 to 127.0 mc. Drag of 15.3 lbs. at 600 mph. Wt. 4.7 lbs.

37X-2 MARKER BEACON ANTENNA — Receives 75 mc marker beacon signal. Drag of 3.5 oz. at 400 mph. Wt. 1 lbs.

FLIGHT CONTROL

AP-101E AUTOMATIC PILOT — Provides automatic pilot services in the heavy twin to four engine airliner range. Flies the aircraft in response to heading signals during cross country and localizer-glideslope signals (including crosswind correction) during approach.

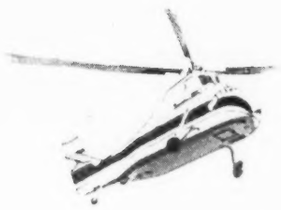
AP-102 AUTOMATIC PILOT — Lightweight automatic pilot with services and installation range similar to the AP-101E.

AP-103 AUTOMATIC PILOT — Collins newest version automatically controls all high performance commercial and executive aircraft including airline and executive jets. Offers continuous radio course crosswind correction, smooth flight over VOR stations, included flight director steering computer circuitry.

FD-104 INTEGRATED FLIGHT SYSTEM — Provides instrumentation for attitude control, flight along selected headings or VOR radials, ILS approaches and flight director steering. Complete plan view and forward view picture of flight is presented on two instruments.

FD-105 INTEGRATED FLIGHT SYSTEM — Advanced version of IFS with two-color horizon background, 4" instruments, integrated lighting and larger warning flags.

FD-107 INTEGRATED FLIGHT SYSTEM — Lightweight IFS utilizing 3" instruments of the FD-104. Computer amplifier in a 1/4 ATR short.



All over the world, Sikorsky helicopters have rescued more people than all other helicopters combined.

(and carried more passengers and cargo, too)

SIKORSKY AIRCRAFT, Stratford, Connecticut, U.S.A.

Sole foreign representative: United Aircraft Export Corporation, East Hartford, Conn., U.S.A.
European Offices: 3/5 Warwick House Street, London, SW1 England

STRÜVER Airfield Refueler
Capacity 10,000 Imp. gals.

A new type of fuel truck solves the problem of rapid and economical refueling for jet-powered commercial aircraft. Here are its characteristics:

Capacity: 10,000 Imp.gals. Delivery rate 750 Imp.gals/min.

Independent control of the individual delivery points through STRÜVER control valves.

Constant pressure at hose end even with varying flow strength. Control pressure can be pre-selected within a range of 20 to 50 p.s.i.

Accurate measurement of fuel quantity for both delivery and return.

Foolproof and rapid fueling, thanks to rational arrangement of fittings.

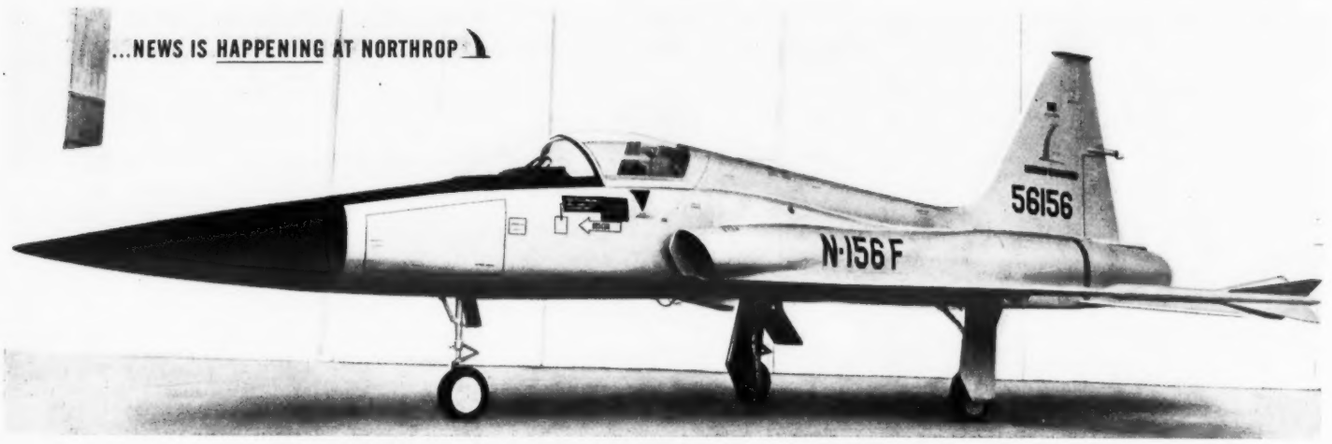
Corrosion-resistant, cantilever light metal tank, hence high payload.

Better water separation and shorter overall length through the STRÜVER patent double wedge shape of the tank.

STRÜVER HAMBURG
TANKWAGENBAU

AD. STRÜVER GMBH TANKWAGENBAU HAMBURG

...NEWS IS HAPPENING AT NORTHROP



N-156F DESIGN CONCEPT DELIVERS ECONOMY...MAXIMUM STRIKING POWER

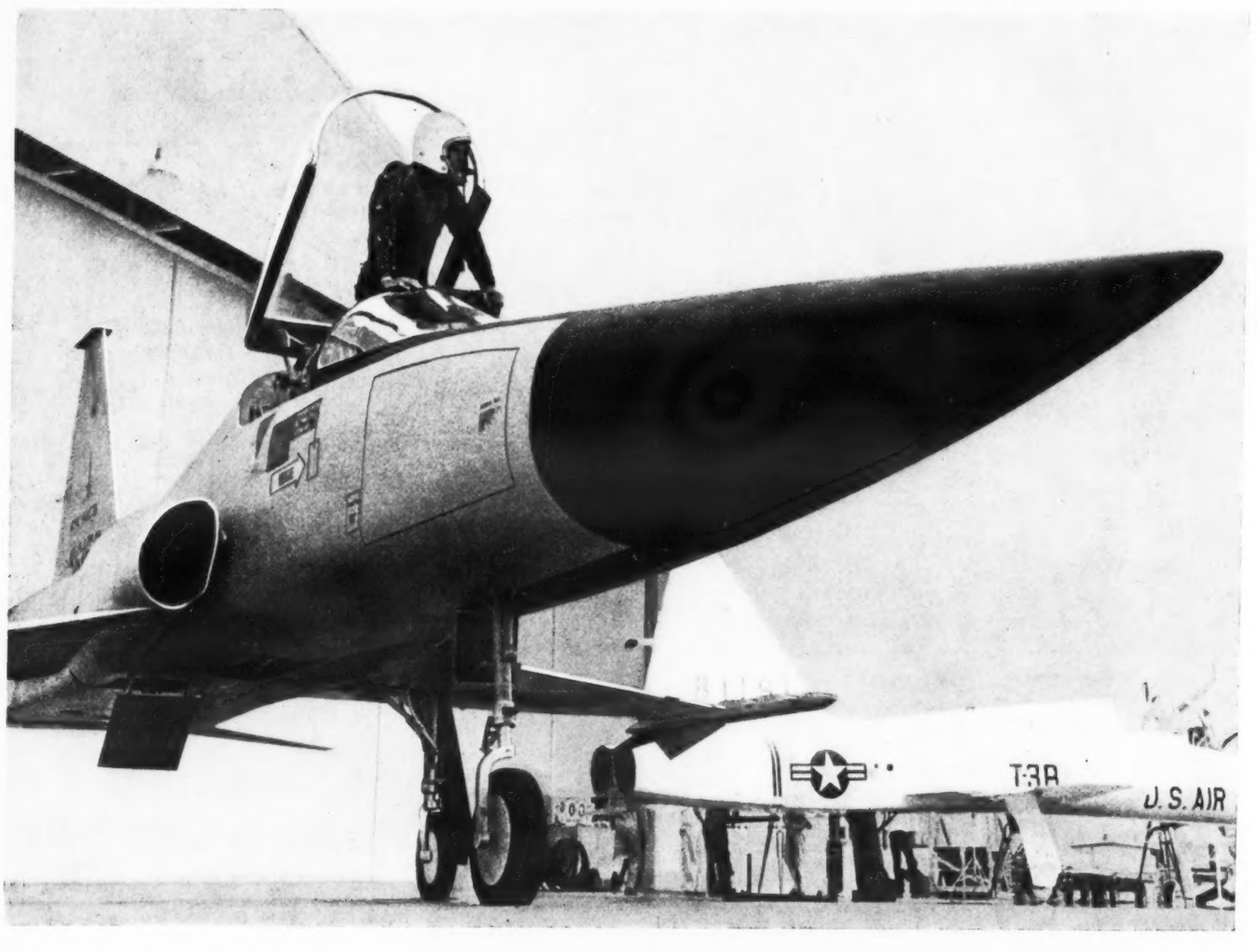
To deliver maximum fighting power within the available defense resources of the free-world nations, Northrop has developed the new, multi-purpose N-156F – the Freedom Fighter. The supersonic N-156F is lightweight, takes advantage of new high-thrust-to-weight jet engines and uses less than half the fuel of comparable U.S. fighters.

In addition, this fighter offers unique logistic and technical advances. The N-156F can operate from short airfields or be adapted for zero-length launch. This mobility contributes to quicker reactions. It permits more aircraft on ready alert along a wider and more dispersed perimeter for maximum striking power–with minimum vulnerability.

Northrop's N-156F has been selected for development by the U.S. Air Force. It is the first supersonic fighter American-designed for specific tactical and economic requirements of other free-world nations. Designed for production outside the United States, the N-156F will make a substantial contribution to the economies of the areas it is designed to defend. *First Freedom Fighter now being manufactured will be flight-tested this year.*

NORTHROP INTERNATIONAL

BEVERLY HILLS, CALIFORNIA, U.S.A.
A Division of Northrop Corporation



Leipziger Allerlei

Aviation and the Leipzig Spring Fair

By E. Baur, Geneva

"Leipziger Allerlei" is the name of a famous local dish consisting of young vegetables, asparagus and mushrooms in a shrimp sauce and garnished with small meat balls or semolina dumplings... This only by way of introduction; more serious topics are coming immediately. But it is certainly gratifying to know that even Leipzig caters for the gourmet.

Without exaggeration Leipzig can be described as the city of the world's most important East-West trade fair. And for the past three years the products of East Germany's aircraft industry have played an important role among the wealth of items on show—in 1959 some 9,400 companies from 49 different countries took stands.

Guest in Leipzig . . .

Immediately on the opening of the Spring Fair, which was held this year from March 1st to 10th, an unending stream of visitors surged through the aircraft industry's pavilion. Here the *VEB Kooperationszentrale für die Flugzeugindustrie*, of Dresden (Cooperative for the Aircraft Industry) and Technocommerz GmbH, Berlin, the foreign trade organization, showed the latest products of the companies grouped together under the *Vereinigung Volkseigener Betriebe Flugzeugbau* (or VVB Flugzeugbau for short; Association of People's Aircraft Manufacturing Plants).

The dominant item in the pavilion was the fuselage mockup of the Type 152 four-jet commercial transport, which is now going into production at the VEB Flugzeugwerke Dresden and will come on to the market in 1960. The attractive cabin equipment shown was similar to that for the 57-passenger normal version of the aircraft. In addition, a first class model for 48 passengers and a tourist class version for 72 passengers are also offered. A cut-away model on a scale of 1:10 gave an impression of the complete aircraft.

This exhibit was supplemented by one of the Pirna 014 jet engines (thrust 6,900 lb.) developed especially for the 152, and by a collection of its major components, such as compressor rotor, combustion chamber and turbine wheel. The engine was developed at the VEB Entwicklungsbau Pirna, but production is in the hands of VEB Industriewerk Ludwigsfelde.

The ASh 82T 14-cylinder two-row radial engine with direct fuel injection (1,930 h.p. take-off rating, 1,625 h.p. rated power), also on show, is being produced in large numbers at VEB Industriewerk Karl-Marx-Stadt for the Il-14P twin-engine short-to-medium stage airliner. Up to the present time the Dresden plant has delivered more than sixty of these aircraft, which—in all probability—will remain in production for some long time to come. Components of the ASh 82T exhibited included a complete crank assembly, a set of connecting rods and the AW 50 four-blade propeller used with the engine.

Finally a selection of equipment items revealed that the German Democratic Republic has reached the international level in this field and is obviously aiming at making the aircraft industry into an autonomous branch of the national economy entirely independent of foreign supplies.

The Technical Fair. Centre, the Indian pavilion.

. . . and in Pirna

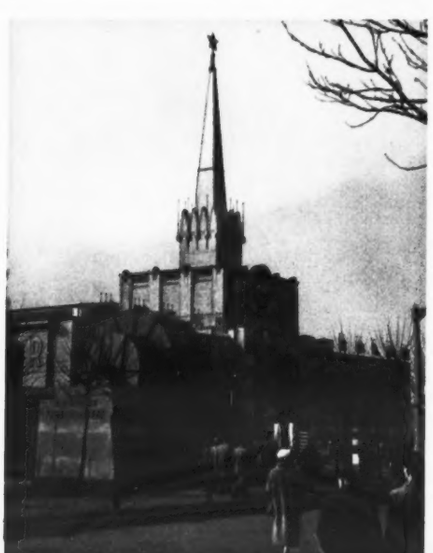
I have to thank my two hosts, Senior Engineer Walter Künzel, General Manager of Technocommerz, and Willi Wolf, sales manager of the Aircraft Industry Cooperative, for the opportunity of paying a brief visit to Pirna, where I was able to supplement the impressions I had already gained of the young East German aircraft industry's activities. The old city on the left bank of the Elbe is dominated

The imposing entrance to the East German aircraft industry's pavilion. In the foreground is the *Libelle* single-seat sailplane for thermal, high-speed and altitude flights. This model is also certificated for simple aerobatics. In the rear is the two-seat FES 530 *Lehrmeister*, for elementary to advanced training. These two sailplanes are in production at VEB Apparatebau Lommatzsch.

The Type 152 is offered in three versions, for 48 passengers (first-class layout), 57 passengers (normal version, picture) and 72 passengers (tourist layout).

The East German aircraft industry's pavilion: rear, the fuselage mockup of the four-jet Type 152 airliner, which is now going into production at the VEB Flugzeugwerke Dresden and will be put on the market next year. Centre, the Pirna 014 jet engine (6,900 lb. thrust) used in the Type 152, and the twelve-stage axial compressor for this engine. The Pirna 014 also has a two-stage turbine and an annular combustion chamber with twelve burners. Fuel consumption at take-off power is given as 0.85 lb./lb.t./hr.

The biggest foreign exhibitor at this year's Spring Fair in Leipzig was the Soviet Union. The monumental Russian pavilion was one of the landmarks of the Technical Fair.



Prime Minister Nikita Khrushchev paid a surprise visit to the Leipzig Fair. Picture shows him with East German Party Secretary Walter Ulbricht (right) and Prime Minister Otto Grotewohl against a background of Sputniks in the Soviet pavilion.

by Sonnenstein Castle, whose spacious rooms house the offices and laboratories of VEB Entwicklungsbau Pirna, the design and development organization.

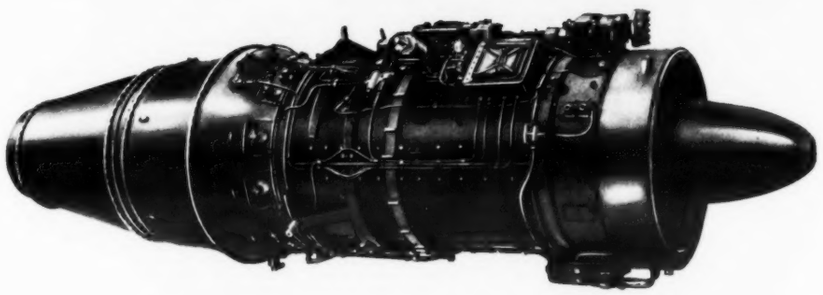
The Pirna organization is responsible for the development of turbine powerplants for air transportation use. In addition to continued development of the Pirna 014 jet, the organization is also working on the Pirna 018 propeller turbine of roughly 5,000 h.p. which is to power the projected Type 153 airliner.

In striking contrast to the venerable old castle buildings are the super-modern workshops and engine test beds which have been erected in record time barely five hundred yards away from the castle. Every technically interested visitor must pay full tribute to the experts who, in the space of four brief years, have created a research and development centre whose planning and equipment is fully up to the best European standards.

An international reception

To reach our next point of call we were driven along the twisty road which follows the course of the Elbe. The vine-covered slopes and the trains of barges on the river made me forget aviation topics for a few moments ... But a road sign pointing to Lommatzsch brought me sharply back to reality. Conversation immediately turned to the plant of VEB Apparatebau Lommatzsch, which devotes its energies to the development and production of sailplanes. *Libelle* and *Lehrmeister* are the names of the two sailplanes now in production, the former being a single-seat high-performance type, and the latter a two-seat model for elementary to advanced training.

I was told that, by comparison with the reference year of 1955, the German Democratic Republic increased its foreign trade to 146 percent in 1958, and that the target figure for 1961 is 178 percent. At a reception in



The Type 152 airliner (four Pirna 014 jets of 6,900 lb. take-off thrust each) for 48 to 72 passengers is now going into production at the VEB Flugzeugwerke Dresden. The production model will differ from the version shown here in two principal points. Firstly, the main undercarriage units will be retracted into streamlined housings on the engine nacelles, and the supporting wheels at the wing tips will be eliminated. Secondly, the windows in the fuselage nose will disappear, to provide room for installation of a radar set. Silencers for the engines are also being developed. The 152 can be operated over stages of up to 1,350 nautical miles; cruising speed is between 430 and 460 knots, and cruising altitude between 33,000 and 36,000 ft. Cabin pressure then corresponds to an altitude of 6,000 to 7,500 ft. Payload 13,850 to 17,500 lb. depending on version; take-off weight 98,100 to 102,500 lb. normal, or 105,800 lb. with overload. Take-off distance to 35 ft. (ICAO standard) 4,315 ft.; landing distance from 50 ft. (for a landing weight of 77,160 lb.) 4,590 ft.

Leipzig, Heinrich Rau, Minister for Foreign Trade and German Domestic Trade, expressed himself as very satisfied with the results so far achieved, in particular by the aircraft industry. Apart from subcontractors, some half dozen undertakings are today working on aviation requirements, and exports of aeronautical equipment are constantly rising, a remarkable achievement for an industry which works entirely for the civil market.

On the evening before leaving Leipzig I had the privilege of participating in a reception organized jointly by the aircraft industry and Technocommerz in the aircraft industry pavilion and attended by visitors from more than a dozen countries. Many leading personalities from the aircraft manufacturing and air transport industry from both East and West followed with close attention the paper read by Professor Brunolf Baade, Technical Director of the East German Aircraft Industry Research Centre, on the development and construction of the Type 152 medium-stage airliner. The discussion which followed with experts from Brazil, Bulgaria, China, Czechoslovakia, Britain, France, Iceland, the Mongolian People's Republic, Poland, Switzerland, USSR, Hungary and Vietnam did much to strengthen the view that, after a surprisingly short "running in" period, the East German aircraft industry has already reached world status in some respects. It is obvious that State investments in this industrial branch have been and still are very generous. In this connection every allowance has been made for the fact that a highly developed aircraft industry presupposes exceptional efficiency in practically all other branches of industry. Modern aircraft not only need highly specialized materials for airframe and engines, but the whole accessories and equipment industry must be of above-average standard if the final product is to be competitive on the world market. Basically the aircraft industry can be regarded as a criterion for the whole industrial development and technical and scientific level of a country.

One of the very modern assembly shops at VEB Flugzeugwerke Dresden, birthplace of the Type 152. The plant also produces the Il-14 P airliner, with two 1,930 h.p. ASh 82T piston engines, which has a cabin for 26 passengers instead of the 18 in the original Russian Ilyushin Il-14 model.

A 152 undergoing a test to destruction at VEB Flugzeugwerke Dresden.

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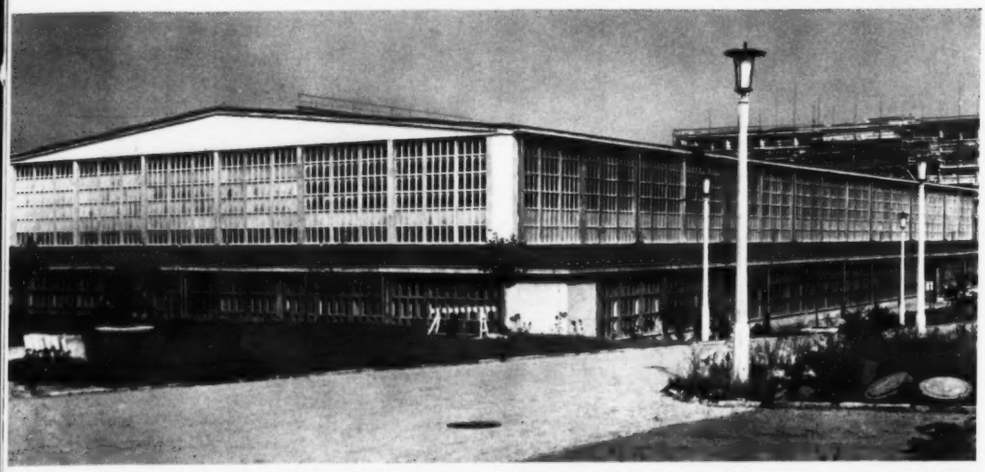
Although as a whole the Leipzig Spring Fair had a strong international flavour, this was less noticeable in the aviation sector. However, the Czechoslovak aircraft industry was represented by Omnipol, the foreign trade organization in Prague, and models of

Test beds for jet engines, compressors and propeller turbines are going up in record time at Pirna, with the aid of substantial State subsidies. Industrial investments in 1959 are to be increased by 20 percent to 15,000,000,000 East German Marks.



Construction work on workshops and test beds at both Pirna and Dresden is scheduled for completion by 1961. Picture shows a workshop at Pirna designed along the most modern lines.

There are some 400 machine tools of the latest type in this shop at Pirna. The machine tool industry in the German Democratic Republic is working at full pressure and, with the exception of a few special machines purchased abroad, supplies virtually the whole of the country's requirements.

the latest PZL-101, PZL-102 etc. sports, training and agricultural aircraft in the Polish pavilion bore witness to Poland's aircraft activities. Finally, Britain was represented in the electrical engineering and communications show by Marconi's Wireless Telegraph Co., while the TRT, CSF, LTT and LMT companies had exhibits on the stand taken by the Centre National d'Etudes des Télécommunications in the French pavilion.

I did not go to Leipzig, however, to inspect the products of the West European industry, with which readers are already familiar. My object was to get a brief glimpse of the activities of East Germany's aircraft industry. These first impressions will then be extended during a more detailed visit to the plants grouped under VVB Flugzeugbau which has been promised me later this year.

From 11 Passengers
to 2 1/2 Million

Air France's Fortieth Anniversary

Passengers wearing hats of "pre-flying" days go aboard a *Goliath* of Farman's 1919 Paris-London service.

The history of air transport in Europe begins in the early months of 1919, when Deutsche Luftreederei opened domestic services from Berlin to Hamburg and Leipzig, and G. Holt Thomas, a pioneer of Britain's commercial aviation, founded Aircraft Transport and Travel Ltd., the earliest predecessor of the British Corporations. However, it fell to the French to open the first international passenger service. On February 8th, 1919, Lucien Bossoutrot took a Société Farman *Goliath* with eleven passengers from Paris to London.

. . . "Passengers" perhaps does not fully meet the case. The eleven persons occupying the hastily converted Farman *Goliath* bomber all wore uniform and carried military travel orders from Paris to London in their pockets. In Bossoutrot's own words, a civil ruse. For weeks the London authorities—who were very sensitive about the Channel—had refused permission for any civil aircraft to fly over British territory "until the Peace Treaty was signed." Finally, the only way out was to put the small party into "warpaint."

Captain Bossoutrot, one of the most outstanding figures in the early days of French air transport—who gained 29 world records and died in 1958, only a few months after Henri Farman—tirelessly continued flying passengers for Ligne Farman. Two days after the return flight from London he carried 13 passengers from Paris to Brussels and six months later he was to be found on a route proving flight to Casablanca and Dakar.

Meanwhile French air transport was taking on more concrete forms. In 1923 three Channel companies merged to form Air Union, soon to be followed by the formation of Air Orient, which stretched out feelers towards the Middle and Far East, of CIDNA (Compagnie Internationale de Navigation Aérienne) which built up a route network in Eastern Europe, and of SGTA (Société des Transports Aériens), which succeeded Ligne Farman. And Aéropostale's Latécoère flying boats prepared the way to South America.

On August 30th, 1933, finally, all these private companies were merged into Air France. Such was the groundwork of France's national flag carrier, which was re-established after World War II, today operating the world's longest route network and in 1958 carried well over 2½ million passengers.

Cabin of the Farman *Goliath* (the first Paris-London aircraft had basket chairs). Passengers could open the windows during flight.

The first Paris-London air ticket made out by Farman was bought by an Englishman, who paid by cheque.

Air freight in 1933: loading goods by hand.

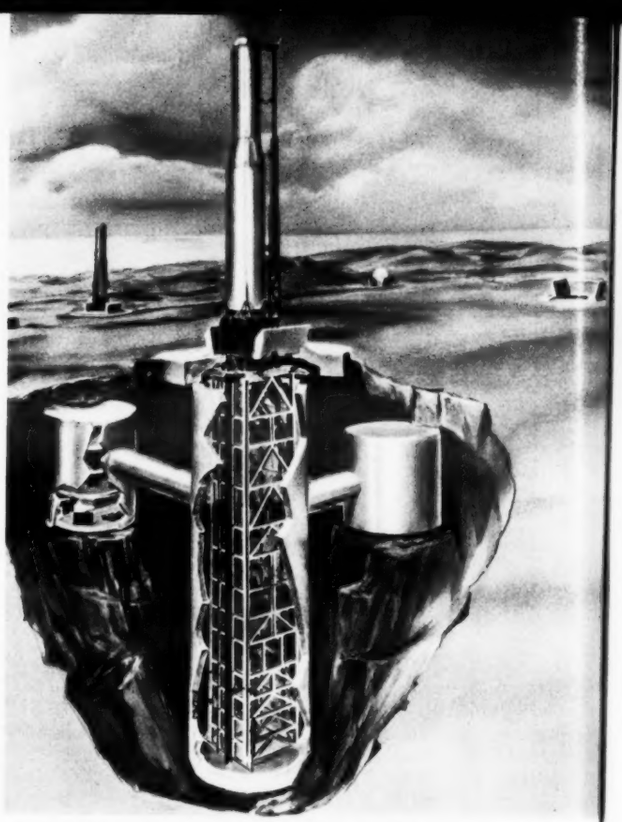
Unlike the Farman *Goliath*, the *Caravelle* does not offer Paris-London passengers the privilege of opening the windows . . . too bad.

Raymond Vanier (left), who has worked for the French airmail organization for 40 years – Compagnie Générale Aéropostale, Air Bleu and since 1946 with Air France as head of the Centre d'Exploitation Postal Métropolitain – has recently retired. Right, *Didier Daurat*, Vanier's predecessor at the Centre d'Exploitation Postal.

In 1954 – 35 years after his first passenger flight from Paris to London – pilot Lucien Bossoutrot (right) made the same trip as a guest, in the cockpit of an Air France Vickers *Viscount*.

Underground Dispersion of Long-Range Ballistic Weapons

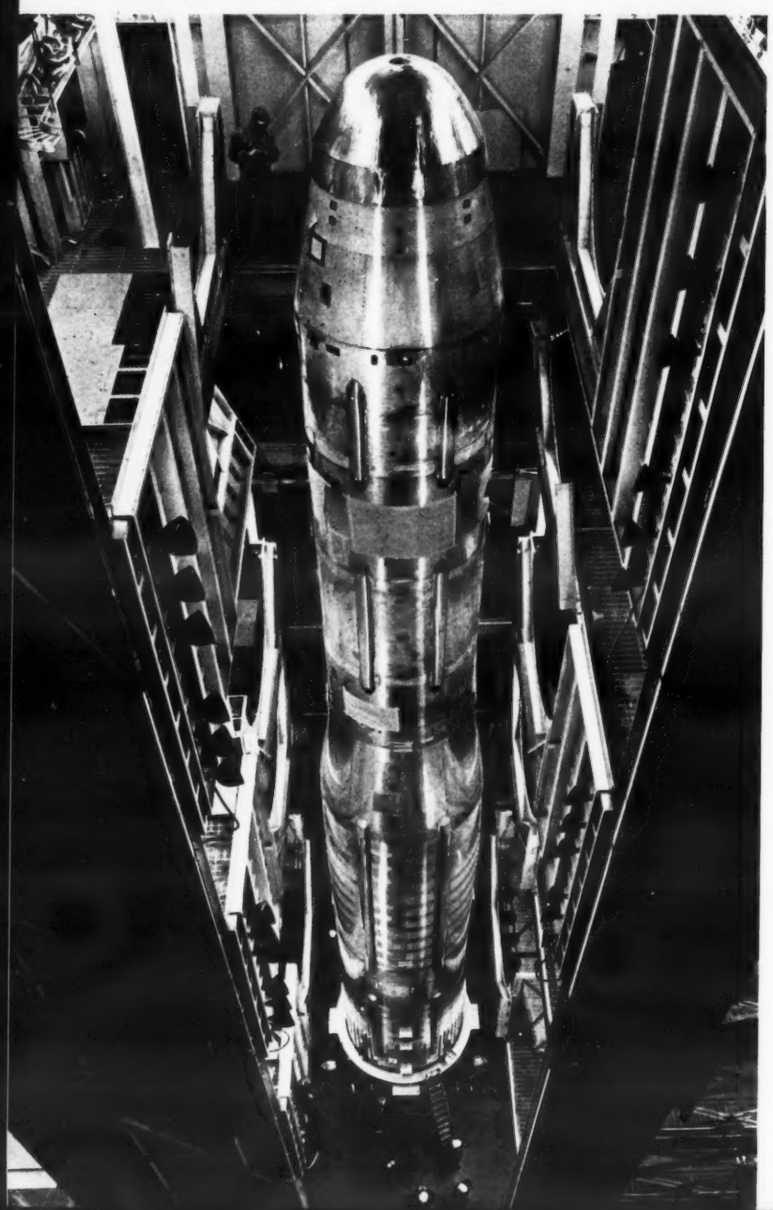
By Eric Burgess, Los Angeles



Underground shaft with elevator and servicing platforms for the Martin *Titan* ICBM. A similar installation is being built by American Machine & Foundry Co. for the USAF at the edge of Vandenberg AFB, California.

The big problem in the current deterrent defence concept is that of ensuring immediate retaliation. This means that the first generation ICBM must be launched in the period between detection of the attacking missile and the time when the launching area becomes part of the stem of a mushrooming fireball. With intercontinental ranges this period is fairly short, a matter of fifteen or twenty minutes. With IRBM it is even shorter.

If it becomes necessary for a defensive nation to fire long-range ballistic missiles in retaliation against an aggressor, every second of countdown is priceless because it brings the incoming thermonuclear warheads four miles closer to their targets. At the present time all IRBM and ICBM bases are soft bases, completely unprotected and easy targets. *Atlas*, for example, is launched from a surface base which is vulnerable to attack by conventional and advanced weapons. This is true also for the *Thor* IRBM. Unfortunately, these large modern ballistic weapons cannot be moved around easily as could the German V2 of World War II. We cannot nowadays use the technique employed by the Germans of choosing a launching site, rushing up the rocket crews and firing the missile, and then moving away before the launching equipment could be located and destroyed. For one thing the guidance requirements are more severe than with the short-range V2, and the launching site needs exact surveying for programming of the guidance system.



View from the top platform of the 100-ft. servicing rig for the *Titan* ICBM. This mighty steel framework is to be used in modified form for underground sites, according to USAF plans.

Launching bases are hard to hide, so their location must become known to potential enemies. It is also obvious that a surprise attack is the most likely opening for a future war, and this attack is going to be directed at the means of retaliation. Although this may be some consolation to the city dwellers it is none whatsoever to the military personnel responsible for the defence of a country or a nation. As they now stand the soft bases do not contribute greatly to the deterrent defence because an enemy has the incalculable advantage of being able to choose when he strikes. To be sure of retaliating, a deterrent defence force of IRBMs and ICBMs must be able to get its missiles off their pads within 15 minutes of the need to fire in anger. Moreover, a potential enemy must be made fully aware of this capability.

Several avenues are being followed to create an effective ballistic missile deterrent. The first is to reduce the countdown. Experience with missiles so far has produced extended countdowns which are unrealistic for defence purposes. The countdown must be accomplished at any time of day or night, in any kind of weather, and under any circumstances of attack, power failure, sabotage, invasion. Moreover it must be achieved within fifteen minutes of the order to retaliate.

This presents several serious problems in connection with propellant loading, checkout of sub-systems, and maintenance of base capability. The long-range ballistic weapon has a number of sub-systems; a flight control system, an airborne guidance system, an electrical supply of both AC and DC, a hydraulic system, a steering system, a propellant utilization system and a propulsive system. In addition, the vehicle carries a complex nose cone which includes a nuclear warhead, arming, fuzing and countermeasure devices. Checkout of all these interrelated sub-systems cannot be accomplished in a few minutes; for a true deterrent defence they have to be maintained in a condition of continuous readiness. Propellant loading must be timed so that

it is completed when all the other sub-systems are ready to go. To ensure maximum reliability, the final checkout of all sub-systems must coincide as closely as possible with the time of fire-in-the-tail. Any residual time delay between checkout of a sub-system and fire-in-the-tail contributes to unreliability of that sub-system so far as the whole weapon system is concerned.

Checkout demands fast propellant loading, and this is difficult for ICBMs because of the amounts of propellant that have to be placed in the tanks in the short time available. The problem is eased by having a continuous propellant loading system to minimize the valving and pumping requirements. This can be accomplished easily with the fuel, but is not applicable to the liquid oxygen. The methods now being developed for fast propellant loading will also be applicable to the second generation liquid-propellant ICBM. The missile's fuel tank will be kept loaded with fuel in sufficient quantity to reach the allocated target. If a last minute change of programme is desired, additional fuel can be loaded during the short countdown. Pressurization containers within the missile are also kept fully loaded and continuously topped to replace losses during checkout and holds. The fuel would be periodically circulated from the missile through the storage tank of the base in order to remove contaminants.

The liquid oxygen cannot be conveniently housed in the missile on a permanent basis. It will be stored in a tank at the base and continuously circulated through filters to remove contaminants. Some oxygen would be passed through a heat exchanger to produce oxygen gas under pressure. This gas, applied to the ullage of the storage tank would be used to displace the liquid oxygen into the tank on the missile. The use of gas pressure for propellant loading overcomes the requirements for large pumps and heavy electrical power loads. A gas pressurizing system would operate in two stages. A low-flow valve opens to fill the loading lines and establish flow into the tank of the missile. As soon as this flow is established the main flow valve would open to permit loading at the rate of at least 2,000 gallons per minute. A computer would be used to programme the loading and thus minimize the weight of the airborne propellant utilization system. This computer would ensure that the main flow is stopped just before the tanks are fully loaded and that the final topping process would take place at a low flow rate with super-cooled liquid oxygen. At the conclusion of the loading process, which could be accomplished in this way in about five minutes, the high pressure oxygen head would be discharged through a dump valve, and only sufficient pressure maintained in the oxygen supply tank for topping up in the closing phases of the countdown and thrust build-up. All tanks would, indeed, be suitably topped during the thrust build-up period and the supply lines would not be disconnected until the instant of lift-off.

If the countdown were stopped for any reason, the liquid oxygen would be returned to the storage tank. If the missile ever had to be removed from its pad for maintenance, the fuel likewise could be restored to its storage tank.

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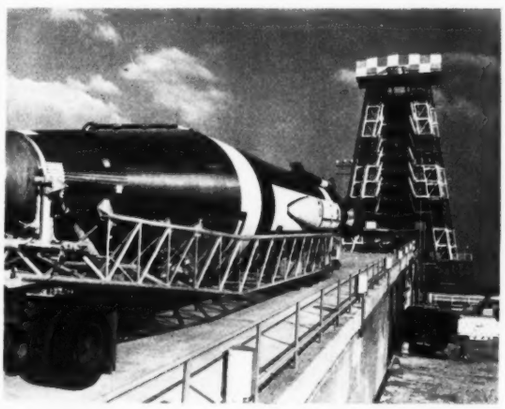
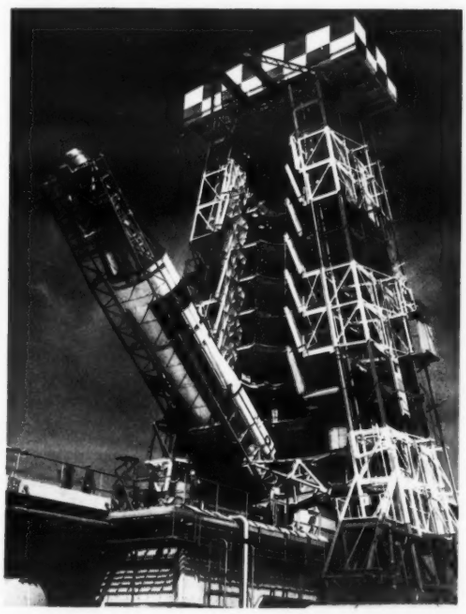
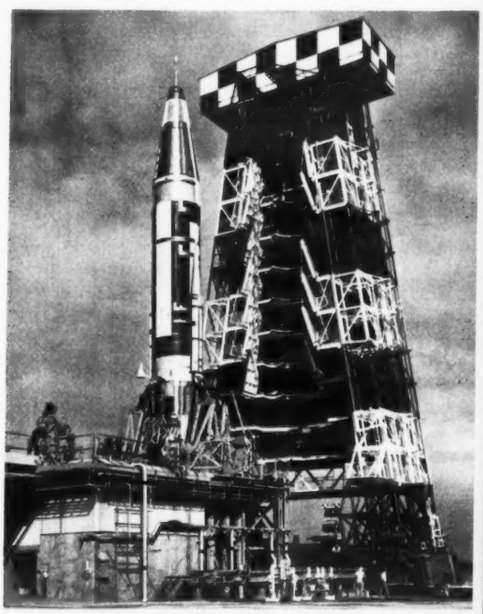
The second method of creating the deterrent is to move the liquid-propellant missile underground into a hard base. With the missile, its checkout, propellant loading, and other ground support systems would also go underground. Pre-launch checkout and propellant loading are carried out in an underground shelter, the missile is raised to the surface by some elevating device, and is then fired. All forms of long-range ballistic missile now appear to be developing towards abandonment of the soft base. The *Titan* liquid-propellant ICBM can be used from hard bases, the *Minuteman* IRBM and ICBM is designed around the hard base concept, while the *Polaris* IRBM will use a mobile base which can be hidden in the ocean depths until required.

There are, naturally many difficulties associated with the hard base, and this type of base is not the complete answer. For example, it is doubtful whether a missile and its launching crew would be operational after the explosion of a nuclear device on the surface directly above the hard base. The ground vibrations could be so intense as to incapacitate the crew and destroy delicate guidance and control equipment in the missile. A hard base, to be effective, must be designed to resist vibration and to minimize the communication of that vibration into its structure.

These pictures of the erection of an *Atlas* ICBM on its launching pad at Cape Canaveral give some idea of the complexity of the ground installations required for the operation of long-range rockets.

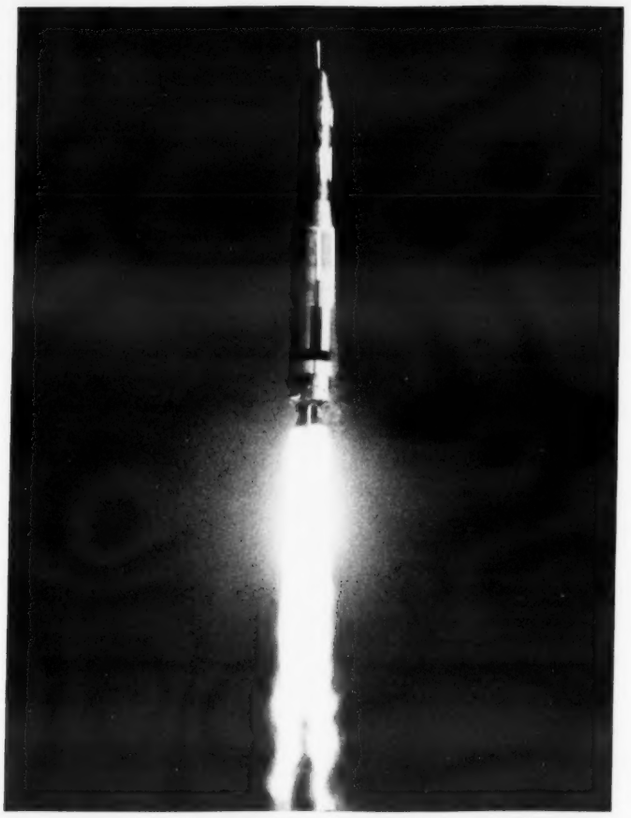






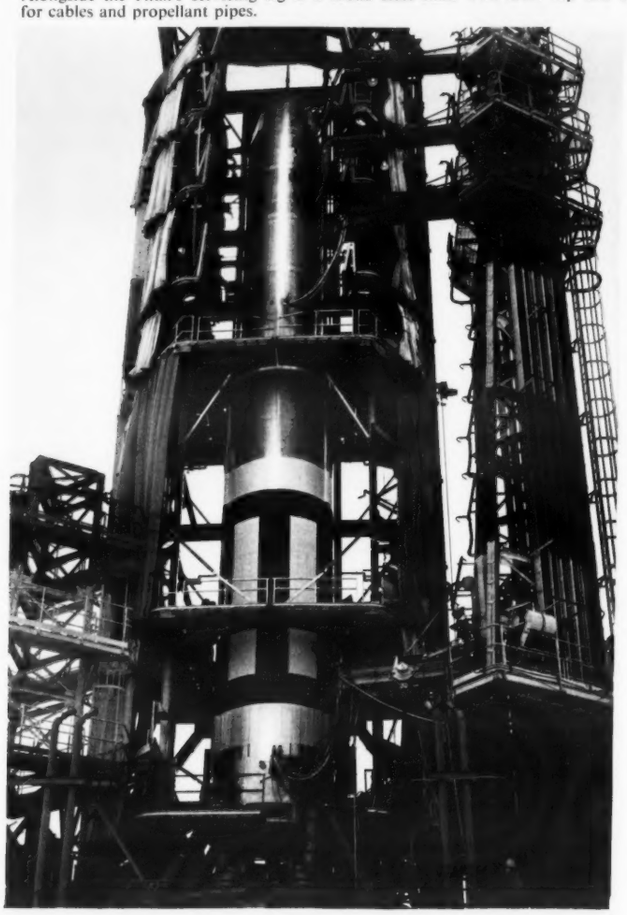
In a hard base the missile will be maintained in a vertical position on its elevating platform. It will be environmentally protected not only from attacking ICBM heat, radiation and vibration, but also from the vagaries of the weather. The missile's fuel tank would be kept loaded, and it would be in a state of continuous checkout. At the order to launch, liquid oxygen propellant loading would commence even as the vehicle was being raised to the surface. Protecting doors would open, the missile would emerge from the ground at the time of countdown completion, and launching would take place.

An underground launching and servicing system for the *Titan* ICBM is now being constructed at Vandenberg AFB, California. This is not an operational system, but will be used for testing and training purposes. The first operational base is planned later for Lowry AFB near Denver, Colorado. A contract for the hard based *Titan* launching system was awarded to the American Machine and Foundry Company. The approach by this company, according to recent releases, is to use a circular pit silo type of structure connected underground to separate chambers in which control and servic-



Launching of a two-stage Martin *Titan*. The two rocket motors in the lower stage together deliver more than 300,000 lb. of thrust.

Alongside the *Titan's* servicing rig is a broad steel mast with arms top and bottom for cables and propellant pipes.



ing functions are housed. The whole complex is to be well below surface level and undetectable from the air. The missile itself will be stored in a vertical position within the main circular pit. The top of this silo is level with the surrounding terrain and is protected by reinforced concrete. The mouth opening is closed by two hinged doors which lift upwards and outwards when the missile is to be raised to the surface for launching. The *Titan* stands on an elevator which is used to lift it to the launch position. It is not fired from within the silo but only when it is raised to the surface. The elevator is protected by flame deflectors, which send the exhaust gases away from the mouth of the silo at the time of lift-off.

Loading of the missile would be very much like loading at a present-day surface launching complex. The missile would be raised into the vertical position from its transporter and placed on the elevator platform. The elevator would then lower it into the silo, where it would be housed and maintained in a state of instant readiness. Problems of propellant feed lines on the elevator are serious, but solutions are in sight. At an AMF meeting in New York during December 1958, General Bernard Schriever said that, although the *Titan* is about 18 months behind the *Atlas* in operational capability, it will have the advantage of the hard base site.

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The third way to achieve instant retaliation capability is to use a solid-propellant ICBM in a hard base. This is regarded by many strategists as the ultimate in the deterrent defence. It is exemplified in the *Minuteman* weapon system.

There is much to be said for this concept; it avoids the plumbing difficulties inherent in the liquid-propellant vehicles, and it takes us one step nearer to push-button warfare. The ideal arrangement of the *Minuteman* will use a continuous checkout system, in which the solid-propellant missiles are deposited in silos and automatically checked out from a remote control station. Dispersal of the launching silos along highways will make them almost invulnerable, and by launching the missiles from within the silos complex elevating systems are avoided.

The *Minuteman* system is basically simple and cheap, and uses a weapon of a basic design that will not become obsolete rapidly. Its design is such that developments and advances made during the next two decades can readily be incorporated into the system. The use of solid propellants reduces the countdown period very much more than is possible with even the most sophisticated propellant loading systems.

The hard launch sites do not include crews and are accordingly more easily protected from near misses by nuclear warheads. Their dispersion makes it almost impossible to destroy the deterrent force by one surprise nuclear attack. The destruction of the hard bases will require 30 to 50 times as many missiles as would be needed to destroy an equal number of soft bases. The *Minuteman* is also cheap compared with its liquid-propellant counterpart. Even the missile costs about one tenth of the liquid-propellant missile. But also it needs only one tenth of the personnel to operate it, so there is a tremendous saving in the cost of the hard base.

A comparison between the requirements of hard bases for solid and liquid-propellant missiles is made in the Table. It is apparent that, although the present-day liquid-propellant ICBM can be adapted to the hard base, the ballistic missile deterrent becomes really effective only when it consists of a solid-propellant vehicle in an automated hard base complex.

Comparison of Requirements for Hard Bases Using Solid and Liquid-Propellant Missiles

Base Requirements	Solid	Liquid
Personnel access	X	X
Personnel living and recreational facilities	—	X
Missile access	X	X
Missile checkout and servicing facilities	X	X
Propellant intake	—	X
Propellant storage	—	X
Propellant loading and topping systems	—	X
Power generators	X	X
Elevator, loading, unloading	X	X
Elevator, firing	—	X
Warhead access	X	X
Warhead storage	—	X
Warhead checkout and servicing facilities	X	X
Warhead loading	—	X
Static test facilities	—	X

An intensive and thorough evaluation carried out with Mk.1 aircraft has paved the way to the current production version, the Mk.3.
Refinements include hydraulically operated services, Martin Baker ejection seats, wing-tip auxiliary fuel tanks and a one piece moulded windscreen. All Jet Provosts are powered by the Armstrong Siddeley Viper turbo-jet.

"The Aeroplane" photo

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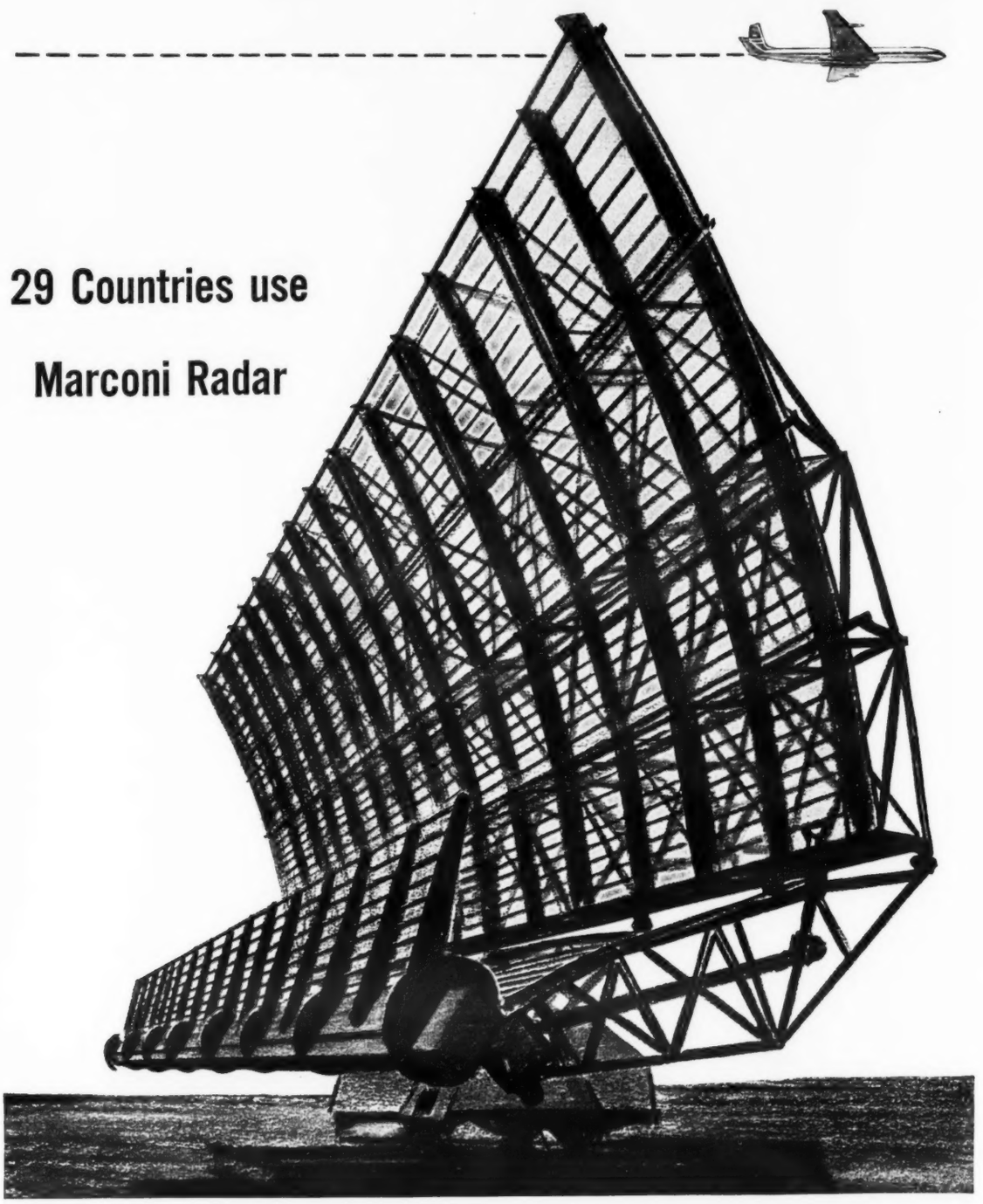

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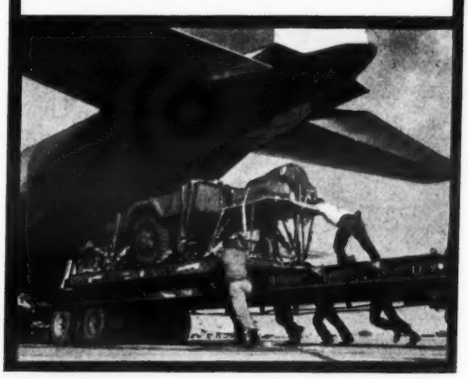

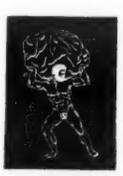

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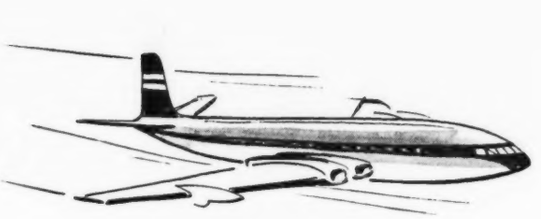

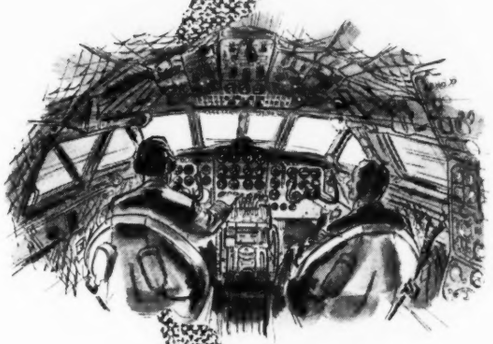

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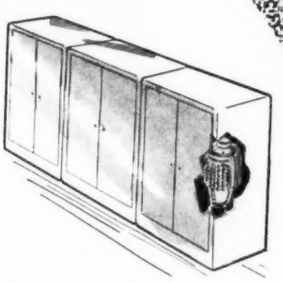

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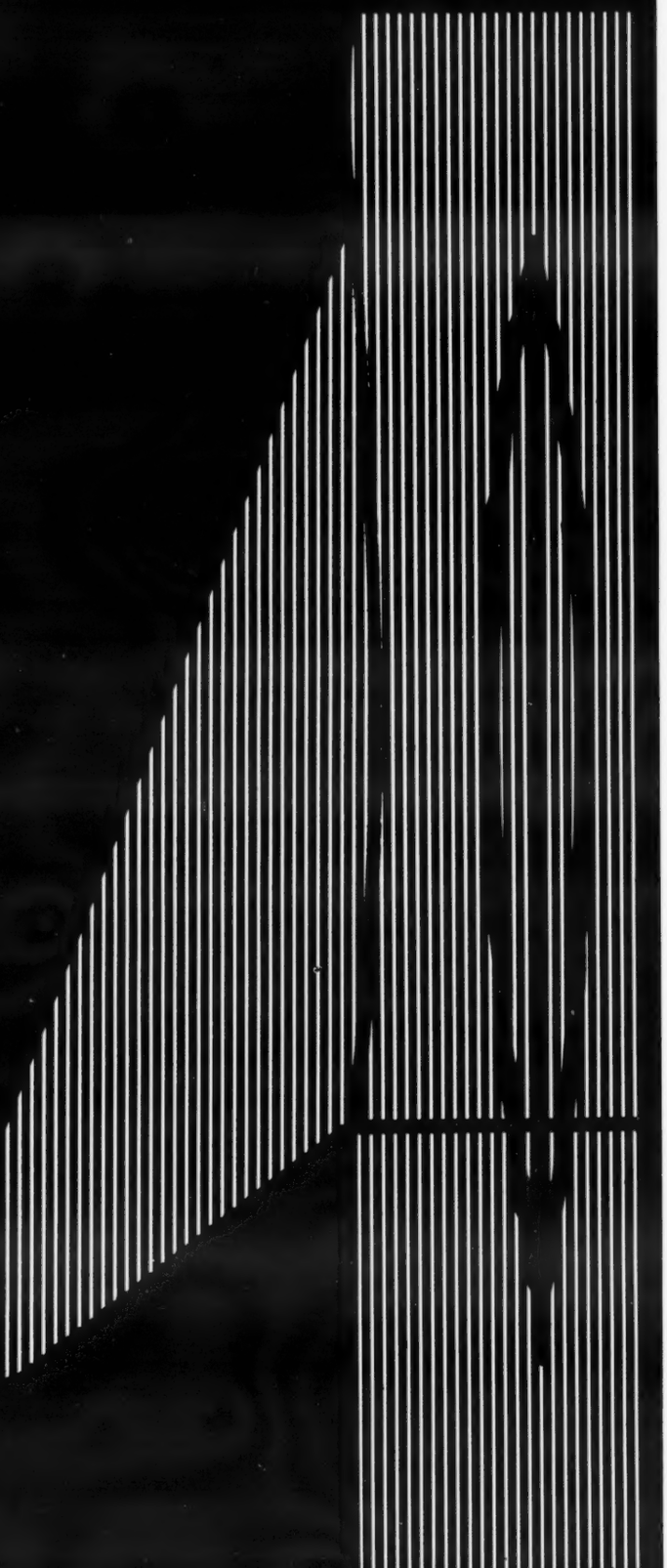

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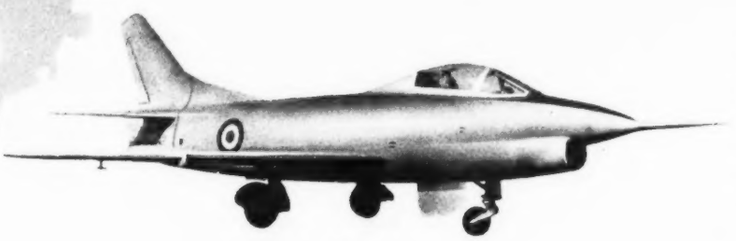

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Ballistic Missile Reliability

By Major Patrick W. Powers, U.S. Army

Ballistic missile "blackmail" is the latest form of diplomacy. It seems to be taken for granted that hundreds of ballistic missiles can accurately accomplish their terrible missions and automatically achieve the desired level of nuclear (or chemical or biological) destruction.

But what will really happen when the "buttons" are pushed? Will these complex weapons of war hit their targets? Are they reliable? These are extremely difficult questions to answer but in the present state of the art, the battlefield performance of these missiles may not be outstanding. What is needed now is an adequate formula for evaluating the potential results so that the missile threat can be placed in the proper perspective. On the other hand, we need a method for determining the effectiveness of ballistic missiles in terms of their probable tactical employment.

The proper definition and understanding of *tactical reliability* can give us the required yardstick to measure the expected results and usefulness of the ballistic guided missile. The calculations of the scientist and the engineer will not help at this point: the product of the reliabilities of the critical components is useless for this application although valuable for design purposes. What is needed is the viewpoint of the military commander in the field. He defines reliability as *the degree of probability that a missile system will detonate the warhead, at an effective distance from the target, at a specified time.*

A closer examination of tactical reliability reveals three distinct functions that must occur *(Figure 1)*. These are grouped into two categories, "preflight" and "inflight", based on launching the weapon at a certain time and accurate detonation of the warhead. The inflight condition emphasizes the role of the warhead, which is often neglected when considering the merits or demerits of a particular missile; all of the other parts of the system merely act as part of the delivery means for this payload.

Preflight reliability

First, consider preflight reliability or firing the weapon *on time*. This means that the missile system must have a high checkout reliability with a minimum of component failures or equipment breakdowns. Time is always critical in a tactical situation. Although the targets are stationary, a coordinated attack by land forces or the destruction of important installations by intercontinental missiles to support attacks in other parts of the globe will require precise timing.

What are some of the lesser known characteristics of a missile system that will insure a timely effect on the target? One of the most important of these characteristics is a rapid and smooth checkout. The rejection rate for components must be kept to a minimum since only a limited number of spare parts can be carried by the missile organization, and there is no time to replace an excessive number of these items. All critical components must have a long life even though the missile is a "one shot" weapon. This extended lifetime of parts is necessary when it is realized that, once the missile and its associated equipment have been checked out, there may be a long surveillance period during which some system components are warmed up and turned off a large number of times. For any attacking or deterrent missile forces, this cycling may occur for days or weeks, or even months—a situation calling for unusually high standards of design and manufacture.

Meeting a firing time also depends on the maintenance of the complex electronic and mechanical equipment. Not only does this involve a training problem but it requires a built-in system of maintenance. This need can be met by module packaging with provision for a defective unit to be quickly isolated and replaced. The supply and repair of major items of equipment must be given the highest priority.

The military operators of the missile equipment are as much a part of the overall system as electronic tubes, gyroscopes or propellants. Men, too, must be reliable, and this can be achieved only by following valid, troop-tested checkout and operating procedures. The commander must insist that there are no deviations from these procedures, which, however, must be adapted to meet the continuous equipment changes and modifications to a system after it is put into operational use, if they are to remain effective. If the missile system cannot accomplish its mission on time, then preflight reliability for that attempt or "trial" is *zero*, just as surely as if the warhead never exploded or the missile was wide of its mark. This also means, of course, that the tactical reliability is zero for that trial.

Let us take an example of ballistic missile firings by way of illustration (see table I). These results would have to be obtained during military training and industry test firings because these are the *only* data that can give an approximation for preflight reliability in battle. Only combat experience will provide valid data, so these figures will be optimistic, since the firing environment during tests is more favorable than that during any tactical situation. In this example, a thirty-minute time bracket is specified as a trial. Note that the missile system failed to make the firing times in trials numbered 3 and 8. The reliability was zero for those trials (or the trials were "unsuccessful"), so that the total preflight reliability was eighty percent for this sampling of launchings. On a time basis, then, eight of the ten were fired within the given thirty-minute time bracket. In combat, the military commander might have failed in his mission in this case, because he lacked sufficient fire support or because he did not detonate enough warheads on distant targets to achieve a desired level of destruction.

Inflight reliability

Too often when discussing missile reliability we lose sight of the only requirement for a ballistic guided missile: to transport an effective warhead accurately to the target. This is clearly emphasized in the two parts of inflight reliability *(Figure 1)*, both of which depend on certain warhead functions.

Proper detonation of the warhead depends, generally, on three factors: the arming of the warhead; the electrical detonation signal from the fuzing system; and achieving the anticipated explosive power of the lethal payload. To further complicate this particular function of tactical reliability, the warhead should be armed only when the danger of an improper detonation to the troops, equipment and friendly areas is minimized. This arming usually takes place at a certain point on the trajectory when the

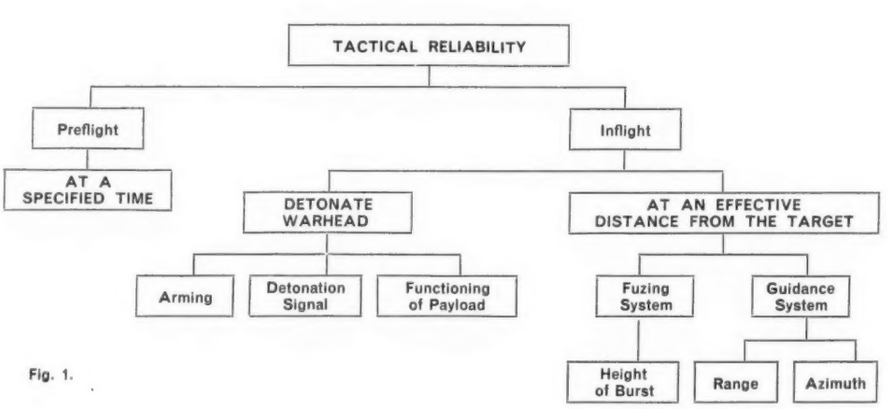


Fig. 1.

guidance system or sensing elements determine that the precise point in space and the correct time of flight have been reached.

Where the warhead detonates is a function of the fuzing system and the guidance system. This is normally a point in space above the target for nuclear warheads, and it is really a three-dimensional problem. A height of burst or vertical dimension is determined by the fuzing system; the range (or distance to the target) and azimuth (or direction) are the horizontal dimensions determined by the guidance system. There is a delivery error in each dimension depending on the specific warhead and on the missile system used. These errors result in a probable error in delivery for a given ballistic missile system which means that, with today's missiles, more than one weapon has to be fired to obtain a high assurance of reaching the desired degree of damage to the target.

As an example, Brigadier General Thomas R. Phillips, U.S. Army (Ret.), wrote recently in the " Reporter " magazine, that the probable error for a 5,000-mile Soviet ballistic missile is ten miles (meaning that half of them will fall this close to the target). He stated that six missiles of this type would have to be fired at an intercontinental target in order to give a ninety-percent assurance of a required level of destruction. Although this may be optimistic, it illustrates how the accuracy characteristics of a missile system require a larger number of missiles to be fired to achieve some measure of tactical reliability.

There is another aspect of accuracy that must be mentioned and that is the difficulty of locating the target with respect to the missile launcher. When the distances are as great as those being considered, present means of location offer insufficient accuracy in many areas of the world. The location should be so precise that the radius of the earth at that point can be computed from standard tables in order to determine the proper coordinates. The range and azimuth are then calculated from the proper set of coordinates. In order to improve these geodetic accuracies, more information must be obtained about the shape and size or " figure " of the earth.

Realistic inflight reliability criteria should be established for military training firings so that a valid evaluation can be made of expected results for present ballistic missile systems. The requirement could be that the missile must generate an arming signal (assuming no nuclear warhead can be used for these firings) and impact within a certain distance of the target. Thus, all missiles impacting outside this arbitrary distance would be " unsuccessful ". The accuracy or miss distance of the *successful* missiles can be stated as a circular probable error or median radial miss distance with a maximum miss distance to include 95 percent of all the missiles fired in the sample trials to be used. This is the only type of approach that can more precisely define a successful inflight reliability trial that simulates a combat situation.

Again, refer to *Table I* for an example of inflight reliability using the same trials as before. Trials numbered 4 and 6 were unsuccessful because of an excessive miss distance. Consequently, only six out of the eight *inflight* trials were successful for 75 percent reliability. As a result, the overall tactical reliability—the product of the preflight and inflight reliabilities—is 60 percent. This may appear to be a low reliability for any missile system, but when all of the factors involved for a tactical firing are considered, it is not surprising that this may be a realistic figure for today's ballistic weapons. In the future, after the relatively few firings (compared with the testing of conventional weapons) that can be made with these expensive missiles, this reliability will undoubtedly improve to a more acceptable degree.

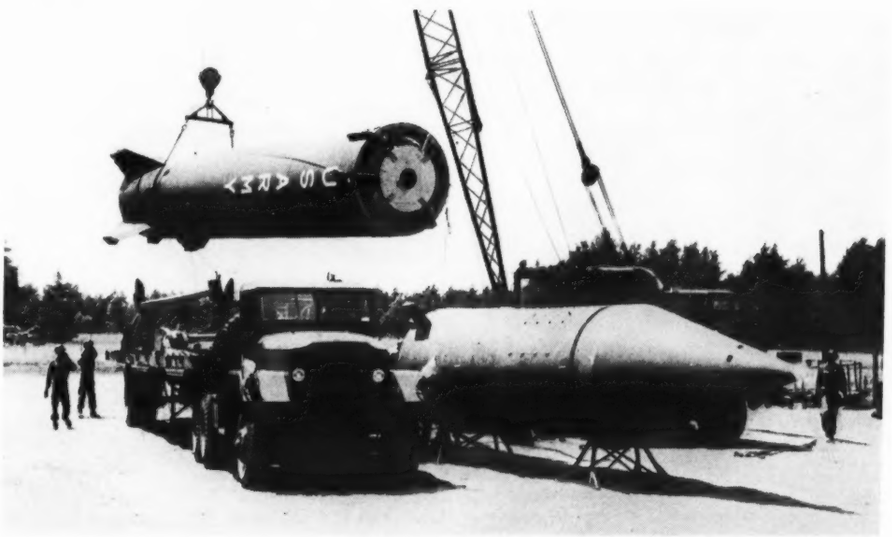
Table 1. Example of Tactical Reliability

Trial number	Preflight successful	Inflight successful	Remarks
1	Yes	Yes	—
2	Yes	Yes	—
3	No	No	Not fired; late
4	Yes	No	Excessive miss distance
5	Yes	Yes	—
6	Yes	No	Excessive miss distance
7	Yes	Yes	—
8	No	No	Not fired; late
9	Yes	Yes	Fired; second attempt
10	Yes	Yes	—

- Actual missiles fired 8
- Preflight (8/10) . . . . . 80 %
- Inflight (6/8) . . . . . 75 %
- TACTICAL RELIABILITY (6/10) 60 %

Placing the 69-ft. missile on the rotating launching pad.

Assembling a U.S. Army *Redstone* rocket.



Once a missile system has been issued to the field, the commander must be assured that tactical reliability will be maintained and improved. This reliability is a function of the reliability of the critical components of the entire missile system *and* of the reliability of the military operators. Without such recognition of these critical reliability factors, the finest research and development missile system will never become a successful tactical weapon.

Conclusion

The pressures of the technological advances of the last two decades have had an astounding influence on the course of warfare and the economic and political evolution of our civilization. The ballistic missile with nuclear warhead is the most ominous product of the resulting weapon race and the one which casts the longest shadow across the continents and the oceans of our planet. But like any other weapon devised by man, it must be better understood so that proper judgment can be made of its changing potential effect as a weapon of war.

By analyzing the ballistic missile in terms of *tactical* reliability, we find that its present effectiveness as an accurate, trustworthy weapon of war is difficult to evaluate. Furthermore, it appears that the many complex functions that must occur for success in combat reduce its reliability far below that of other weapon systems such as the rifle, the aircraft and the tank. Thus, ballistic missile " blackmail " for attacking specific targets may not be as much of a threat as the Communists boast.

On the other hand, we must learn to measure the dimensions of performance of the Free World's ballistic weapons, not in terms of research and development firings but by the requirements of the military commander in the field. Effective tactical reliability for these missiles requires a greater development and production precision and higher standards of military training and employment than in any other weapon system. These requirements must be stressed or the ballistic guided weapon systems will have doubtful effectiveness in any conflict, at least for several years to come.

Notes from the Flight Deck

by "Albatross", London

Wanted : simpler instruments

Just six years ago I signed on to deliver some piston-engined fighters to a Middle Eastern Air Force. I had never set eyes on the type—except in pictures. And for a day or so before the first ferry I pored over the pilot's notes, memorizing every figure I thought I would need to know: pressures, temperatures, frequencies, speeds.

Halfway between Benina and Nicosia, the oil pressure dropped off the clock. With 250 miles of sea still to cross, the future did not seem particularly bright. Still, the engine turned on sweetly and the oil temperature stuck, steady as a rock, just where it was meant to stick: a sure indication that the pressure was normal and that it was the gauge that had gone wrong.

From that day to this I have been at a loss to understand why I have constantly had to refer to temperatures and pressures in degrees Centigrade, Fahrenheit, pounds, kilos, inches of mercury and millibars, when some simple standard could tell me precisely what I wanted to know.

The cockpit of a modern airliner is crowded with dials—it is like a harem, with the pilot, like a sultan, expected to know the personal secrets, whims and wants of everyone. With the mass of administrative detail he must attend to—flight planning, communications, national anomalies to international air traffic procedures, ever-changing prohibited areas, defence exercises, to mention but a few— this is an enormous burden for him to carry.

Much of the information a pilot needs can only be indicated in figures: speeds, vectors, atmospheric pressures, etc. That is accepted. But is it absolutely essential for instruments referring to the mechanical aspects of flying to be calibrated in that manner ?

Most pilots would agree that it makes not the slightest difference whether the needle of an oil pressure gauge points to a numerical value or a coloured quadrant. The story it tells is precisely the same. The advantage of the latter form of presentation, however, lies in the fact that it demands no memorizing, no reference and most important, no added attention. Green is a recognized human standard for safety and normality, the " Go Ahead " signal, and as such commands the correct psychological reaction. Likewise, red stands for a further automatic reaction: emergency, abnormality and " Stop ", whether it be in Tokyo, New York or Barcelona.

A numerical value has none of these qualities. It is artificial.

It could be argued that a pilot accustomed to a particular aircraft would not need such simplification. But no matter how well we are schooled in a subject, there are moments when we forget. Especially at critical periods when there are a thousand and one things to think about.

There is a crisis in the sky today, and the only way we can ride it is by simplifying every facet of the pilot's overcomplicated job. The most obvious place to start is in the cockpit.

A lot of work has gone into attitude and navigation instrumentation, and the results are very promising. But they are taking time to perfect. Meanwhile the big jets are bearing down upon us with their problems bubbling in their wakes, yet so concerned are we with them that the simplest approach to alleviating the pilot's mental indigestion is being overlooked.

Pressures and temperatures connected with the mechanics of an aircraft are strictly for ground engineers. What pilots want are simple, coloured quadrants showing the limits within which they must operate: yellow for caution, green for normal operation and red for emergency.

Although some engine instruments carry coloured indications already, crews are still expected to refer to figures. The reverse should in fact be true, numerical values being directly related to the needs of servicing engineers who must have them to diagnose irregularities.

Aviation has come as far as it has because the men behind it wanted it to. Practically anything can be done if you want to do it. Do we want to simplify the pilot's job and so relieve his mental indigestion ? If we do—let's be rational and start with the obvious.

The perils of drifting snow

High on the list of items now being investigated by aeromedical men is a type of vertigo caused by optical illusion during landings in drifting snow.

A common occurrence in northern territories where runway lights are kept blazing even in daylight during the winter months, it is said to result from snowflakes drifting across the landing path, between the flares and the windscreen.

The danger of this situation is that drifting snow gives a pilot the impression that he is flying straight when in fact he may be drifting off the runway. The effect is said to be particularly marked just before touchdown and during the early stages of the landing roll.

Numerous accidents have been caused in this way, and until comparatively recently they were attributed to pilot ham-handedness and inexperience since the effects are only marked in cross-winds.

To minimize the risks, operators in northern lands are warning their pilots to double-check on each other during the line-up and the roll-out.

Landing on foam

Since Boston Airport threw in runway foaming as an additional emergency landing facility for aircraft with jammed undercarriages, airline pilots have been in a quandary.

Is runway foaming just a clever psychological gimmick, or is there something in it? Does runway foaming really minimize fire-risk when landing wheels up, and if it does wouldn't it be wise to have the facility made mandatory at all major airports ?

So run their questions.

Their uncertainty is understandable, for little has been said about the practice. But then, that too is understandable; for the fire-fighting experts are not certain themselves just how effective it actually is.

According to the Committee on Aviation and Airport Fire Protection set up by the National Fire Protection Association of America, caution should be exercised in adopting the procedure. For although some emergency landings on foam have been successful, almost an equal number have not.

Experience has so far shown that foam will minimize friction sparking and the ignition hazard in the event of a post-impact spill, but there is no evidence as yet to show that it will be as effective should a fuel spill occur on impact. The behaviour of fuel on a foam blanket is not sufficiently well known.

Numerous questions have arisen as a result of Boston's action —believed to be unique in civil aviation—which stems from a military brain-wave to lay a foam tape to assist fighters with cocked nose-wheels to land without damage.

Right now the NASA, the United States Navy and the National Fire Protection's Committee on Aviation and Airport Fire Protection are studying the problems presented and expect to publish results some time this year.

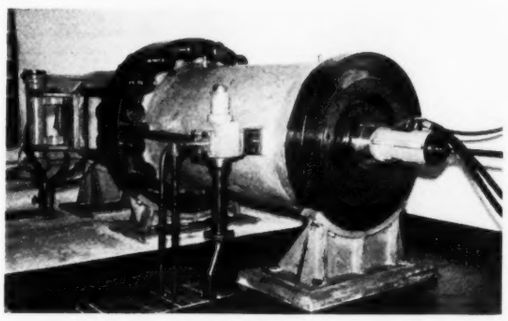
Meanwhile operators are instructing their pilots to use discretion in asking for a foam blanket at Boston; for they are bearing in mind these factors:

It takes up to 20 minutes to foam an area 3,000 feet by 40 feet, a further 20 minutes to replenish the foaming truck which must be available in case of fire after the landing, the possibility that conditions may change in the 40-minute time lapse to make a touchdown impossible, the fact that after asking for the facility a few months ago, an airliner landed short of the blanket.

Cost of the operation, which cannot be put into effect in high winds or cold weather, is about $750—more, if a greater area is to be foamed.

Recent Products of the Equipment Industry

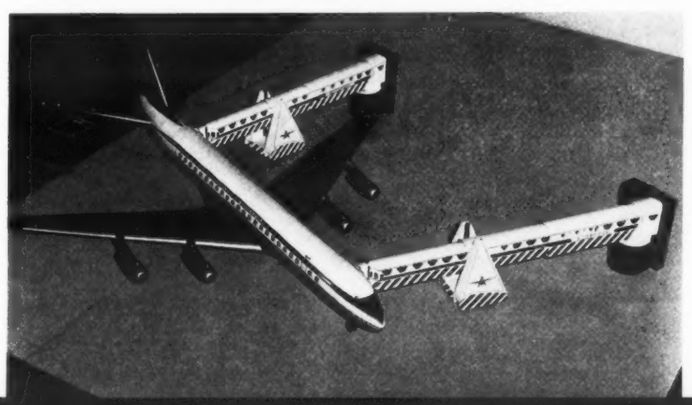
● **The Maintenance Branch Planning Office of British European Airways** has evolved a new rational method of treating aircraft with de-frosting fluid before take-off. By using two Bedford 7-ton truck chassis, on which are mounted 40-foot Simon's hydraulically actuated operating towers and spraying equipment, it is possible to defrost all the external surfaces of a *Viscount* in less than 30 minutes. The defrosting compound, which is a mixture of Kilfrost DC 2 and water, is preheated according to requirements up to 70°C in a special 1,000-gallon storage container, and then transferred to a tank installed in the truck. The fluid is delivered through flexible pipes to 6-foot lances.



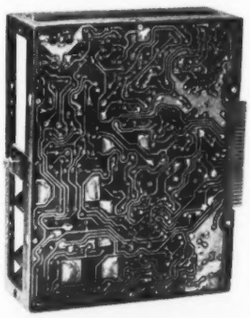
● **Bombrini Parodi-Delfino (BPD),** a private company with head office in Rome, a branch in Milan and plants at Colleferro, Ceccano and Castellaccio, has announced details of its production programme. It includes the manufacture of artillery and small arms ammunition, military rockets, solid propellants for JATO auxiliary units and guided missiles, all types of explosives, metallurgical and mechanical products, chemicals for agricultural and industrial uses, and a whole range of synthetic materials. In the field of guided missiles BPD has concentrated for many years on the development and production of double-based propellants. Recently installed research and production plant has permitted the large-scale production of various types of solid propellants for rockets and missile powerplants. BPD is also engaged in the development of composite propellants, and has been studying small and medium-calibre unguided missiles. The complete missile, i.e., body, propellant and warhead, can now be manufactured entirely within the company's facilities (picture shows an Orth extrusion press as used by BPD for double-based solid propellants).

● **Siemens & Halske A.G.,** Berlin and Munich, announces its *Cerberus* ionization fire warning system which detects fires at a very early stage. Contrary to most other well-known fire warning systems, *Cerberus* does not respond to temperature rises, but reacts immediately to visible or invisible combustion gases, which are formed as soon as an object begins to glow or smoulder, i.e., before actual flames appear. The gas-sensitive "electric feeler" in *Cerberus* is a chamber containing air ionized (i.e., rendered electrically conductive) by means of a radium preparation. Once combustion gases enter this chamber, the electrical conductivity is reduced and the control centre gives alarm. Siemens & Halske has developed a small control centre for use with both ionization and temperature warning systems. A single ionization warning element fitted in the roof of a hangar, for example, can protect an area of from 215 to 1,080 sq.ft., depending on the type of building and the fire risk. Recent models of the *Cerberus* are equipped with a glow-lamp as warning indicator, so that a threatening fire can be detected at its point of origin.

● **Aviolanda Maatschappij voor Vliegtuigbouw N.V.** has announced the design of its *Aviobridge*, a telescopic covered gangway which can be extended from terminal exit directly to the aircraft's entry door. The *Aviobridge* is designed to fit practically all types of modern airliners. Three telescoping sections permit the bridge to be extended to a maximum length of 100 ft. Further details: easily adjustable horizontally and vertically to fit aircraft of various sizes with the aid of a hydraulically-operated supporting vehicle on rollers, positioned under the second section of the bridge. Hydraulic servo system to make the bridge automatically follow the rise and fall of the aircraft when it is being discharged or loaded. Main characteristics: maximum length 100 ft.; minimum retracted length 50 ft.; height inside smallest section 7 ft. 4 in.; width inside smallest section 5 ft. 4 in.; maximum height of deck from ground 13 ft.; minimum height of deck from ground 3 ft. The **Aviobridge** is designed to be operated under extreme weather conditions, up to wind velocities of 60 m.p.h.; maximum load capacity 45 lb./sq.ft.



● **Lear Incorporated** recently introduced the NAVCOM series of new weight and space saving airborne navigation and communications equipments, particularly suitable for installation in single- and twin-engined private aircraft. One component of this series is the Lear NAVPAC 100 for VOR/LOC navigation and marker beacon reception, with aural indicator. Switching from VOR to ILS Localizer is automatic. The NAVPAC 100 is adaptable to any VHF receiver having VOR/LOC capability, and is capable of operating three meter loads and two flag alarms; it can also operate two meter loads and two warning flags and an approach coupler without additional amplification. Maximum overall dimensions are 3 in. × 7.25 in. × 9.5 in; weight 4.5 lb. The upper picture shows the automatic VOR/LOC switching relay (bottom left), while the lower picture shows the etched circuitry of the NAVPAC 100.



Book Reviews

Experimentelle Untersuchungen an verschieden stark konvergenten, schlanken Rotationskörpern bei mässig hohen Überschallgeschwindigkeiten. — By Hans Rudolf Voellmy, Dr.sc.techn. — Communication No. 24 of the Aerodynamics Department, Federal Institute of Technology, Zurich; edited by Prof. J. Ackeret. — Verlag Leemann, Zurich (German; 82 pages, 37 illustrations; price 17.60 Swiss francs, DM 17.00).

The doctor's thesis submitted to the Federal Institute of Technology, Zurich, describes H. R. Voellmy's experiments to check the validity limits of certain simple equations used in the calculation of forces on slender bodies of revolution in the supersonic range. The author's measurements have shown that boundary layer effects have such a powerful influence on flow round the body that the forces covered by the classical hydrodynamic theory become less important than the forces arising from the viscosity of the air. This condition occurs in particular when the stability of the boundary layer is disturbed either because of the body's excessive angle of attack or because of over-rapid thickening of the boundary layer due to the convergence of the body's rear portions. In his final remarks Dr. Voellmy states that, within the Reynolds number range of 1.0×10^6 to 1.2×10^6 discussed, the hydrodynamic theory can be applied only to bodies whose cross-sections increase in the direction of flow and whose angle of attack in relation to the direction of flow is less than approx. 3°. At higher Reynolds numbers, however, it can be applied to somewhat larger angles of attack and to bodies with cylindrical portions. Ba.

A Study of Several Aerothermoelastic Problems of Aircraft Structures in High-Speed Flight. — By John C. Houbolt, Dr.sc.techn. — Communication No. 5 of the Department of Aircraft Stress Analysis and Lightweight Structure, Federal Institute of Technology, Zurich; edited by Prof. M. Rauscher. — Verlag Leemann, Zurich (English; 108 pages; 24 illustrations; price 12.45 Swiss francs, DM 12.00).

In the present doctor's thesis on aerothermoelastic problems, the author gives special emphasis to dynamic aeroelastic effects. The first part of the report deals with temperature, stress and stiffness analysis and gives a review of the thermal aspects of high-speed flight, with regard to both external and internal flow. At the same time he gives a résumé of the basic equations of elasticity, modified to include temperature effects. In the second part of the thesis Dr. Houbolt places emphasis on aeroelastic phenomena and concludes with a fairly exhaustive analysis of the problem of panel flutter before and after buckling. Ba.

Solid-Propellant Rockets, Second Stage. By Alfred J. Zaehringer. — American Rocket Co. (to be ordered from Box 1112, Wyandotte, Michigan), 1958 (English, printed in manuscript form; 306 pages; price $8.25 plus postage).

The author, a contributor to a number of American publications on jet propulsion and rocket questions, makes no secret of his enthusiasm for space travel and rocket technology. He has painstakingly collected all the available non-classified information on solid-propellant rockets, which he published in a first edition of his book in 1955. He has now added five new chapters, including more recent developments, and has published a second edition entitled, in trade jargon, "Second Stage". Beginning with the early days of powder rocket technology and with German, American, British and Russian work during World War II, Zaehringer describes some of the fundamentals, the processing and testing of solid propellants and applications of such rockets. The text is supplemented by a large number of drawings, photographs and tables composed by the author. Occasional inaccuracies in designations and data are compensated by an extensive list of references at the end of each chapter and by an overall bibliography including 800 references. Re.

Fundamentals of Advanced Missiles. — By Richard B. Dow. — John Wiley & Sons, Inc., New York, 1958 (English; 567 pages; price $11.75).

First a word on the author: Richard B. Dow, a Ph.D. in physics from Harvard University, was a ballistician at the Aberdeen Proving Grounds in Maryland during the war, then joined the Guided Missiles Research and Development Division of the Navy Bureau of Ordnance and is now Aeronautical Research Administrator for the Air Force Office of Scientific Research, Washington.

His book deals with the scientific bases for the development and assessment of tactical supersonic missiles, ballistic missiles and space vehicles, treats their operational characteristics and gives representative applications of the basic principles. Chapter headings are as follows: 1. Kinematics of Flight (with discussion of typical flight paths); 2. Application of Fluid Mechanics to Aerodynamics and Propulsion (including propellant and combustion problems); 3. Dynamics (oscillations, automatic stabilization, launching and control systems); 4. Some Applications of Probability and Statistics; 5. Properties of Microwaves (important tube and antenna functions); 6. Application of Infrared Radiation; 7. Radar; 8. Guidance (including navigation and homing systems); 9. Guided-Missile Systems.

In view of rapidly rising development and production costs, Richard Dow's remarks on technical planning and analysis of modern missiles will find a ready audience. Although not every lay reader will be able to find his way among the equations and formulae, these fruits of long practical experience can be unreservedly recommended to engineers and military experts. Re.

Pathfinder. — By Air Vice-Marshal D. C. T. Bennett, C.B., C.B.E., D.S.O. Published by Frederick Muller Ltd., London, 1958 (English; 287 pages; illustrations; price 18 shillings).

This is a highly personal account by a distinguished officer of his flying experiences both in pre-war civil flying and with the Royal Air Force.

Air Marshal Bennett's story begins with his early upbringing on his father's cattle ranch in Australia and moves on to his selection for flying duties with the Royal Australian Air Force and subsequent transfer to the pre-war RAF.

Canoe-surfing among the powerful breakers on the beaches of Eastern Australia—with treacherous undertows and sharks lending added spice to the element of danger—fostered an early love of adventure and the sang-froid so necessary for operational flying.

Outstanding airmanship and an unusually receptive brain enabled this officer to rise rapidly. Organizing skill and ability to lead men brought further promotion to air rank. With the founding of the Pathfinder Force his contribution to the allied bomber offensive was unsurpassed. Tu.

Moon Trip. — By William Nephew and Michael Chester. G. P. Putnam's Sons, New York; Longmans, Green and Co., Canada, 1958 (English; 63 pages; price $2.50).

The big print and basic English presentation, by these two heads of Lockheed Aircraft Corporation missile research teams, will give youthful enthusiasts the chance to catch up on space travel problems of the future. The basic principles are examined relating to radio-activity, blast-off, weightlessness, re-entry into the earth's atmosphere, and the associated high temperature difficulties brought about by kinetic heating of the rocket ship hull. It is all explained so simply that even older readers could brouse over the illustrated pages of this book and perhaps refresh their knowledge of this so topical subject. Tu.

Secret Bomber. — By Wing Commander "Sandy" Powell. Published by Allan Wingate, London, 1958 (English; 215 pages; price 13s 6d).

Whether Mack Maguire, the test pilot of the Atlantic Aviation Company is at the controls of their new top-secret Mark III Alpha bomber, delving into the inner workings of the design office, driving his 4½ litre Bentley, or merely quaffing the odd pint at the "Talbot" with the Chief Designer's secretary, the reader is allowed to share the author's enthusiastic approach to these varied topics. Tu.

Dynamics of Flight. — By Bernard Etkin. Published by John Wiley and Sons, Inc., New York, 1959 (English; 433 pages, 4 appendices and index comprising 80 pages; price $15.00).

This comprehensive work contains up-to-date techniques for dealing with stability and control problems in easy-to-read language. There is full mathematical treatment with numerical examples for the more sophisticated reader.

So many NACA (NASA), RAE, and other technical reports are continually being produced that this carefully considered review of existing data provides a timely contribution to this particular field of aeronautical science.

There are chapters on static stability and control, general equations of unsteady motion, the stability derivatives, stability of uncontrolled motion (longitudinal and lateral), aircraft response to control actuation, turbulent air problems, and automatic stability and control.

Subjects treated include transient and frequency response, feedback systems and automatic controls, dynamics of missiles, machine computation (analogue and digital), and mathematical aids. Tu.

Fighter Planes that Made History. — By David C. Cooke. G. P. Putnam's Sons, New York, and Longmans, Green and Company, Toronto, 1958 (English; 72 pages; price $2.50).

All you could wish to know of the outstanding fighter aircraft, including World Wars I and II and some of the more recent "local wars". Each plane is described in outline together with a brief account of its operational background. Performance and dimensional data are conveniently summarized. There is a full-page photograph for each of the aircraft described. Tu.

An Airplane in Every Garage. By Daniel R. Zuck. Published by Vantage Press, New York, 1958 (English; 192 pages; price $4.50).

This is a highly imaginative, forward-looking book whose author has looked into some of the questions likely to arise if and when there will be "an airplane in every garage". Tu.

Handbook of the Aircraft Industry. — Edited by J. L. Naylor and T. F. Saunders. Published by George Newnes Ltd., London, 1958 (English; 335 pages; 145 diagrams and illustrations; price 35 shillings).

The editors of this book have collated information providing an essential background for those requiring a general knowledge of aeronautical subjects with particular reference to the British aircraft industry.

There are sections on such varied subjects as aeronautical careers, education and training, the more important people in the British aircraft industry, an historical section, and a general review of the various aspects of aviation engineering, including research and development and guided missiles.

There are too, for the more general reader, short papers by acknowledged experts in the fields concerned outlining in simplified terms some up-to-date aircraft design principles. This information indicates the range of problems existing in the industry, if not their ultimate solutions.

Short sections are also included on British civil aviation and aircraft types. Finally, there are several useful appendices relating to the more common aeronautical terms and abbreviations. Tu.

Von Richthofen and the Flying Circus. — By H. J. Nowarra and Kimbrough S. Brown. Edited by Bruce Robertson. Published by Harleyford Publications Ltd., Letchworth, Herts., England, 1958 (English; 139 pages; 6 appendices comprising 64 pages; profusely illustrated with photographs, maps, etc.; price 45 shillings).

A detailed account of the courage and daring of Manfred Freiherr von Richthofen — the 'Red Knight'. Here, too, is the full history of the 'Flying Circus'; more than just a story of air battles and duels to the death, it contains, too, the day-to-day activities of Richthofen and his *Staffel* leaders.

The character and personality of von Richthofen are carefully examined. His early service in the 1st Regiment of Uhlans as a young cavalry officer blooded him for the air combats where ultimately—after some eighty-four victories to his credit—he was destined to be shot down by Captain A. R. Brown, D.S.C., R.A.F. The 'Red Knight' was buried by those who flew and fought against him with full military honours. Tu.

Books received

Flughafen-Abfertigungsgebäude. — Published by the Arbeitsgemeinschaft Deutscher Verkehrsflughäfen e.V., Stuttgart, 1958 (price DM 18.00).

Technisch-Planerische Voraussetzungen für die Anpassung der Flughäfen an den Düsenluftverkehr. — By Dr.-Ing. Werner Treibel. — Published as Report No. 2 of the Arbeitsgemeinschaft Deutscher Verkehrsflughäfen e.V., Stuttgart Airport, 1958 (price DM 15.00).

Research reports issued by the North-Rhine-Westphalia Ministry of Economics and Transport; edited by Under Secretary of State Prof. Leo Brandt; Westdeutscher Verlag Cologne and Opladen, 1957/58:

Report No. 390: Berechnung der optimalen Leistungen, Kraftstoffverbräuche und Wirkungsgrade von Luftfahrt-Gasturbinen-Triebwerken am Boden und in der Höhe bei Fluggeschwindigkeiten von 0-2,000 km/h und vorgegebenen Düsenausströmgeschwindigkeiten, by Dr.-Ing. Johann Endres (price DM 24.90).

Report No. 444: Einfluss der Saugrohrabmessung, der Einlassteuerlage und der Grösse des Kurbelkastenvolumens auf den Ladungswechsel eines Einzylinder-Zweitakt-Dieselmotors, by Dr.-Ing. Werner Wilhelm (price DM 22.40).

Report No. 471: Der Überdruck-Windkanal in Aachen, by A. Naumann, A. Heyser and W. Trommsdorff (price DM 11.00).

Report No. 493: Versuche an Wirbelstrassen hinter Zylindern bei hohen Geschwindigkeiten, by Prof. Alexander Naumann and Dipl.-Ing. Heinz Pfeiffer (price DM 11.65).

Report No. 578: Einfluss der Fluggeschwindigkeit auf die Wirtschaftlichkeit von Strahltriebwerken und Raketen, by Dr.-Ing. Günther Fellner (price DM 15.00).

Report No. 588: Untersuchungen über den Einfluss der Auspuffrohrabmessungen auf den Ladungswechsel einer Einzylinder-Zweitakt-Vergasermaschine mit Kurbelkastenspülung, by Dr.-Ing. Werner Wilhelm (price DM 18.40).

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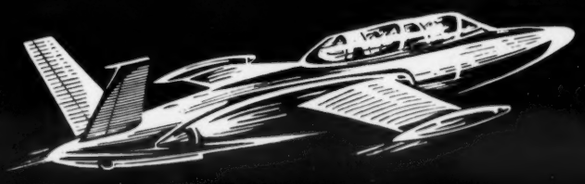

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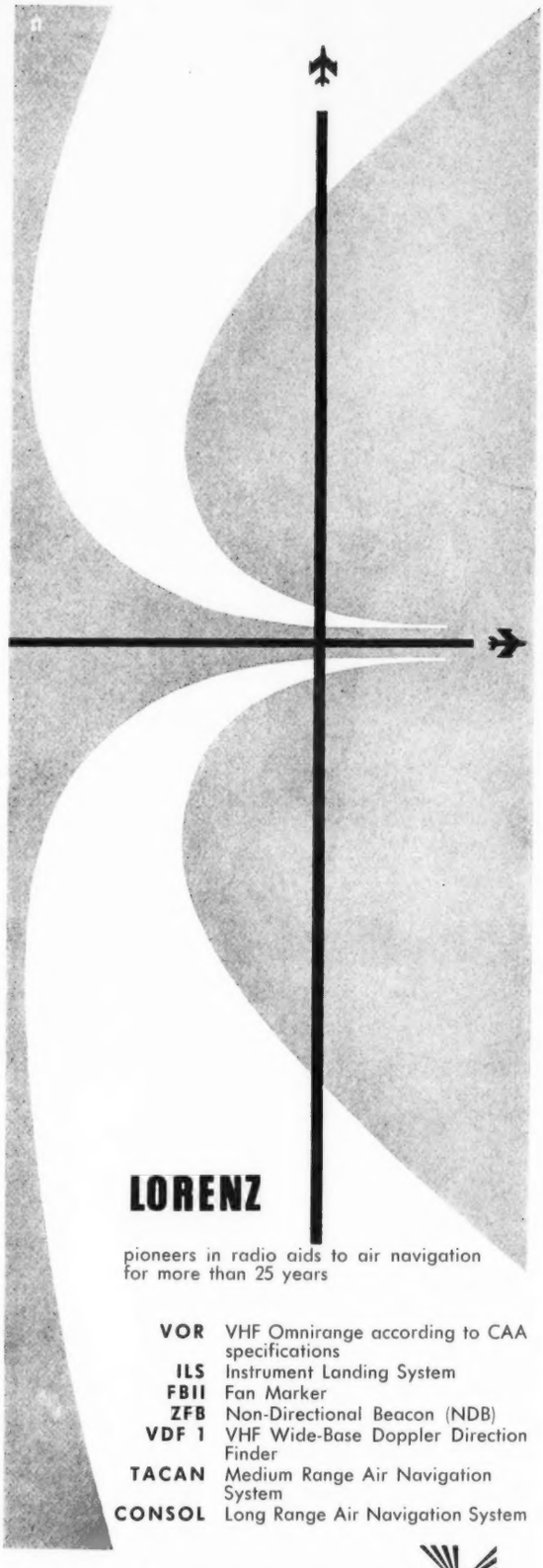

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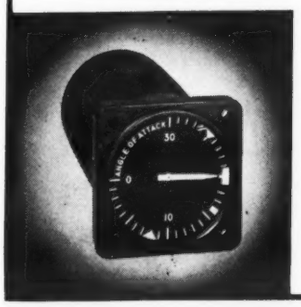

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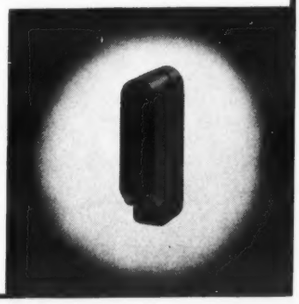

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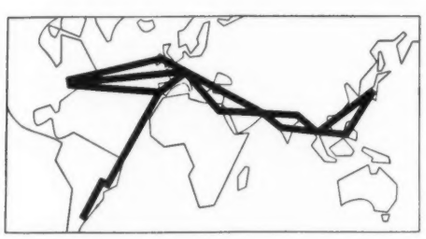

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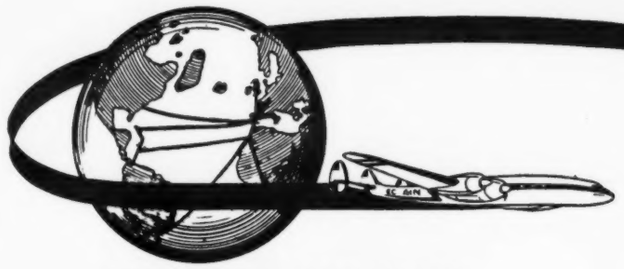

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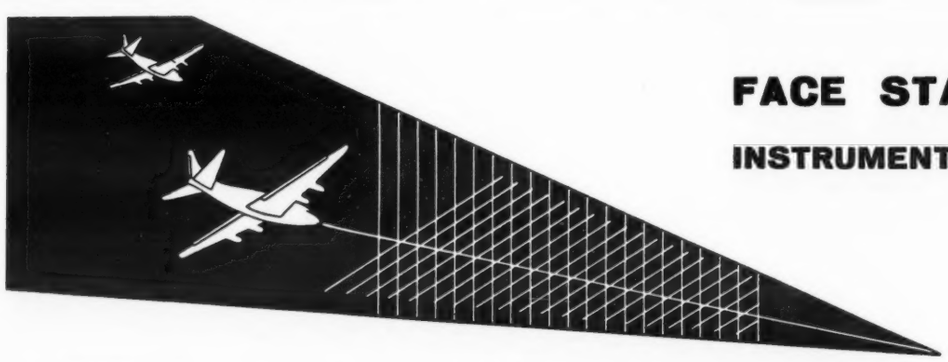

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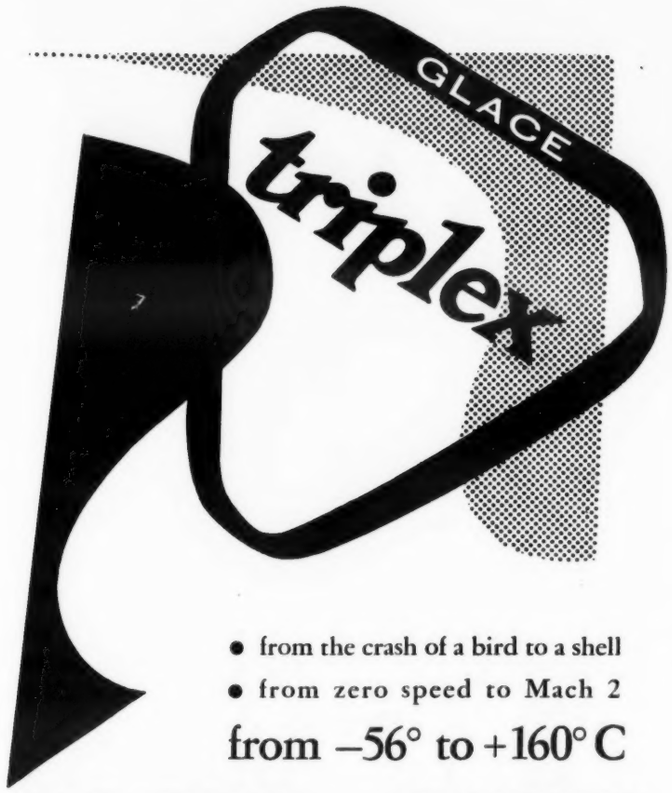

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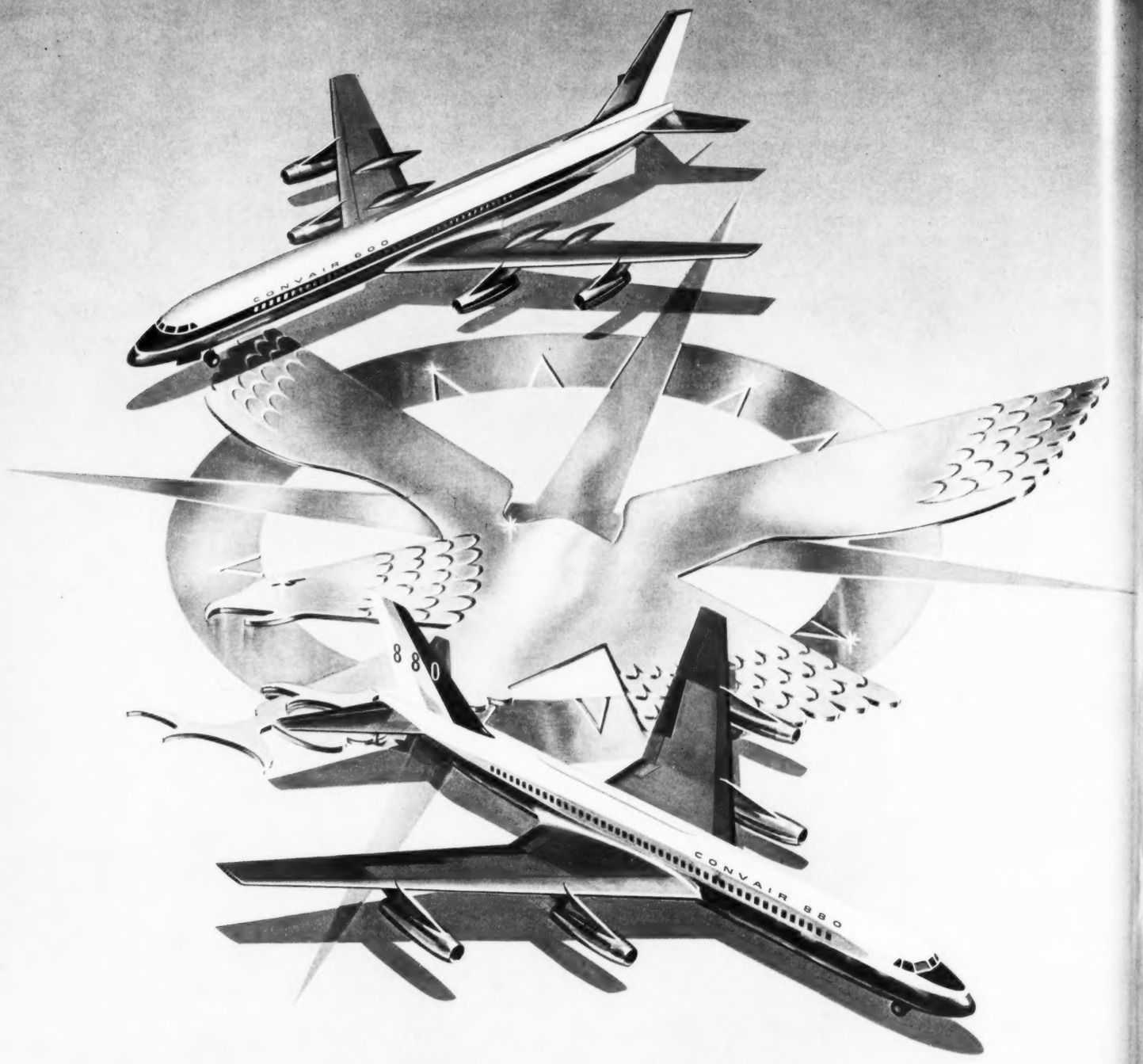

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